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THE MAXIMUM SEPARATION OF STUDENTS INTO TWO PROGRAMS OF COURSE WORK IN A COLLEGE OF AGRICULTURE BY DISCRIMINANT ANALYSIS INVOLVING CERTAIN SELECTED MEASUREMENTS [1]

GIL F. SAGUIGUIT

The major problem was to effect maximum separation between two groups of students who enter and are able to graduate from two programs of course work in the College of Agriculture of The Pennsylvania State University, on the basis of a linear combination of high school graduation rank and scores on tests of aptitude, vocational interest and personality. The subsidiary problems dealt with the separation of recognized subgroups on the basis of the same measurements. A descriptive phase was designed to study separation beyond college into the occupational pursuits of the graduates.

The technique of discriminant analysis, which was related to the theory of regression by the introduction of a quantitative manufactured variate y to represent the criterion for each of the groups that were separated, was the main statistical technique used to solve the major and subsidiary separation problems. The discriminant functions were tested for significance at the .05 level. All calculations were done with the use of PENNSTAC, an electronic computer. The major discriminant function was validated and its predictive efficiency was determined by applying it to a 98-individual sample drawn from the class of 1959.

A questionnaire survey was made to determine how the occupational placement of each graduate corresponded to his college program of course work.

The major discriminant function found was:

$y = -0.1367X_1 + 0.2201X_3 - 0.3055X_7 + 0.0066X_{12} + 0.2011X_{14}$.

When tested it was highly significant. This function shows that the program A students (biological and agricultural science) had higher high school graduation rank (X_1); higher 4-part total score (X_3) on the Moore-Castore Aptitude Test which includes algebra; higher science and engineering group score (X_7), but lower social service group (X_{12}) and social science teacher (X_{14}) interest scores on the Strong Vocational Interest Inventory than the program B students (general and applied agriculture). The function when applied to the validation group made seven correct for every three wrong classifications. This was significant by the chi square test.

[1] General Contribution No. 910. Part of doctoral study conducted at The Pennsylvania State University, University Park, Pennsylvania, U.S.A.

Four other analyses involving the determination of maximum separation between recognized subgroups within the two major groups were made. The discriminant functions derived from these determinations were found to be significant.

The findings of significant separations between the two major groups and between recognized subgroups provide information useful in counseling a student confronted with the problem of choosing a curriculum or of deciding to transfer from one curriculum to another. A student's y value when compared with the critical score shows the program of course work or the curriculum in which he belongs.

The results of the survey of the graduates indicated that many factors affect job placement in fields other than those consistent with the separation in college classification or program completed.

One of the biggest problems which face colleges today is the reorganization or modification of programs of study and curricula in order to provide the best possible education. This problem is solved, in part, by curriculum experts who formulate or construct "streamlined" and "tailor-cut" programs of study or curricula. However, the question of who should be admitted into these programs arises. Fortunately, there are counseling divisions who aid each student in selecting a curriculum. These divisions have a wealth of data on student characteristics. But again, a guidance worker is at a loss because while he usually has information that may indicate the probable success of the student (expressed generally in grade points, scholastic average, etc.) from the regression equation, he has none indicative of the proper classification or the group to which the student belongs. It is this latter kind of information that the present study sets out to determine by a relatively new statistical tool.

PROBLEM

The problem of this study is: Can students who enter and graduate from two programs of course work in a college of agriculture be separated on the basis of available measurements of their aptitudes, personality traits, vocational interests and high school graduation ranks? In a more technical manner, the problem is to determine a linear combination of the measurements that can be used to separate the said students. If the measurements on a set of n-variables tend to occupy different regions of the n-dimensional space defined by the n-variables, then classification or separation is possible.

A descriptive phase of this study was planned to adduce evidence of the separation of the groups of students beyond college

and to determine the use of the measurements involved in this study in the choice of a curriculum.

In stating the problem of the study, it was assumed that a dichotomous situation defined by factors other than those used to establish if officially, exists in the College of Agriculture, The Pennsylvania State University. These factors are measurements made on the students who enter and are able to graduate from the curricula listed under each of the programs of course work. It was further assumed that a linear combination of these measurements can be used to separate the groups of students objectively and efficiently in so far as aiding these students to make curricular choices is concerned.

This study has the following purposes:

(1) To determine a linear combination of certain measurements of students' high school graduation ranks, aptitudes, personality traits and vocational interests that will separate two groups of students who follow two programs of course work in the College of Agriculture of The Pennsylvania State University. The linear combination will not directly indicate the program to which a student belongs but it will serve to determine, in a linear dimensional space, a critical dividing point between two groups of students. The combination of measurements will be tested for significance of discrimination, and validated with the use of a sample different from the samples from which it was derived.

(2) To determine, on the same set of measurements, linear combinations that best separate recognized subgroups within each of the programs of course work. Each combination is to be tested for significance of separation.

(3) To adduce evidence of separation beyond college of two groups of students who finished curricula under each program of work and to determine the use of measurements in the choice of an undergraduate curriculum.

(4) Indirectly, to provide a check on the validity and usefulness of the set of measurements made on students entering the College of Agriculture every year.

The use of a relatively new and unused statistical technique, that of discriminant analysis, may pave the way for its application on many problems of classification in education and psychology.

Owing to certain restrictions on the samples of students used in this study, the interpretations of the findings will be limited but

at the same time, the analysis of the problems will be more rigorous. Allowance should be made for a certain amount of inadequacy that might have been incurred in the quantification of the qualitative data used in this study.

REVIEW OF PREDICTION STUDIES

Prediction studies on college achievement, covering the period from about 1912 to 1952, were made by Parres (1955). Kinney (1932) and Segel (1934) surveyed the studies undertaken prior to 1934, and Duflinger (1943), from 1934 to 1942. Harris (1940) reviewed factors affecting college grades and reported that high school grades and intelligence tests ranked first and second, respectively, as the best predictors of college level academic achievement. In these four reviews, correlational analysis was the primary statistical tool employed, using mainly zero order correlations. These prediction studies were expressed in terms of grade-points, first term academic average, semestral average, and others. Among the prediction variables used in these studies were high school academic average, high school graduation rank, scores on aptitude and vocational tests, home background, parental occupations, economic status, extra-curricular activities, study habits, and kind of high school from which graduated.

Prediction studies using correlational analysis as the primary statistical tool were conducted by Crawford (1936), Crawford and Burnham (1946), and Parres (1955). Cain *et al.* (1950) think that differential prediction may be more promising than prediction on a college- or university-wide basis. Predictive studies in professional schools were summarized by Stuit *et al.* 1949) who reported that correlations between intellectual factors and success in professional studies were high. Each profession was considered separately in this study and only a few comparisons between various professions were made. Blum (1947) studied education, law, journalism, medical and engineering students on the basis of several measurements obtained by a questionnaire, the MMPI and the Strong Vocational Interest Blank. He employed the techniques of correlational analysis and analysis of variance, with two alternatives: first, several groups and one measure and second, one group and several measures were considered. Another possible alternative would have been several groups and several measures simultaneously.

Bonner (1956) extended regression analysis when he cross-validated the regression equations resulting from his study. Parres (1955) undertook a differential prediction study and contended that regression derived for separate curricula are more useful than those derived for an entire college or university. Chahbazi (1956) introduced conventional prediction variables and "achievement motivation scores" obtained for each student in his study, through the administration of the "Sound Stimuli Test" and the "Picture Stimuli Test." In these studies, the criterion was the scholastic achievement expressed in grade points or academic average for a term or semester. The primary statistical technique employed was correlational analysis. Multiple regression equations, recommended for predicting scholastic achievement of freshmen entering institutions where these studies were conducted, were formulated.

Many studies were conducted to determine a linear combination of variables to predict scholastic achievement. Regression equations were formulated for prediction purposes. However, Bryan (1950), Rulon (1951), Tiedeman *et al.* (1951), and Tatsouka (1956) noted the insufficiency of information provided by prediction studies involving regression analysis in the solution of guidance problems.

THE DEVELOPMENT OF DISCRIMINANT ANALYSIS

Johnson (1949) stated that in classification problems, the traditional method of computing the significance of the difference between the means of groups taking each character separately, is inefficient in that it does not take into account the inter-relations existing, if any, between the characteristics dealt with. The problem, therefore, is that a weighted sum of the measurements is needed as in multiple regression. In classification problems, the nature of the criterion is qualitative rather than quantitative as in the case of multiple regression. The dependent variable is a dichotomy or a multiple classification, which can be quantified by following the procedure suggested by Kendall (1946). The particular statistic needed in a multiple classification problem is the discriminant function and the technique is known as discriminant analysis.

Rulon (1951) emphasized that ". . . no matter how the discriminant analysis turns out, whatever it says is new information not supplied by the original prediction technique."

A short historical perspective of the early background of the technique of discriminant analysis was given by Brown (1947). The

first application of the discriminant function seems to have been that of Barnard (1935) on craniometry, following the suggestion of Fisher (1936), who showed the relation of his work and that of Hotelling (1931). Fisher gets the credit for the development of the discriminant function.

A geometric portrayal of the concept of classification by the discriminant function is shown in figure 1.

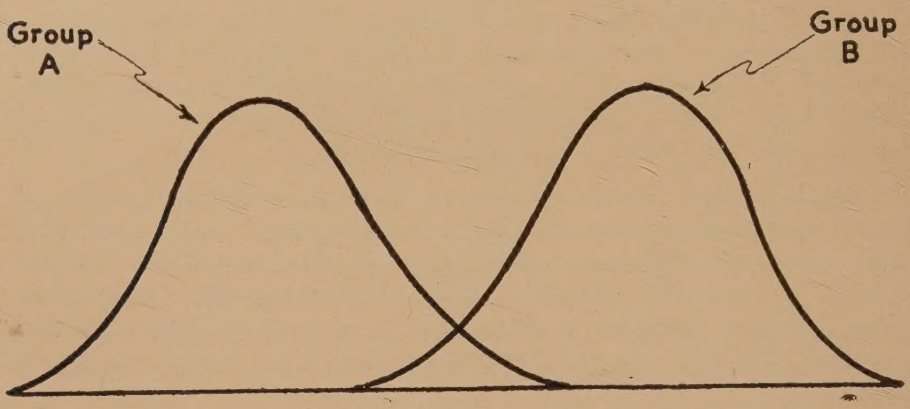

Fig. 1.—Theoretical distribution of discriminant values of two normally distributed groups.

Curves A and B represent the respective distributions of the discriminant function in two groups of individuals. The area of the overlap C can be shown to be an inverse function of the ratio which the discriminant function maximizes. The relative chances of misclassification can be controlled by an accurate determination of a critical acceptance value of the discriminant function. Provided the discriminant function has the same distribution in both groups, except for the difference in its mean value, misclassification can be equalized and reduced if the critical value is the grand mean of the discriminant functions of the members of the two groups.

The technique of discriminant analysis is analogous to that of multiple regression analysis; the difference lies in the qualitative nature of the criterion.

Kendall (1946) showed that the computations in the determination of the discriminant function are identical to those in solving for a multiple regression equation except that in the former, a con-

struct or a formal variate y is introduced as the criterion for each of the two groups or classes in the dichotomy. Kendall also showed that the discriminant function can be analyzed as for the regression equation by testing the ratio $R^2/(1-R^2)$.

The general form of the discriminant function is:

$$y = a_1x_1 + a_2x_2 + a_3x_3 \ . \ . \ . \ + a_nx_n,$$

where the x's are the measurements of the different characteristics and the a's are the weights which will produce the maximum separation between groups.

It is now possible to classify individuals into more than two classes by means of linear discriminant functions. In craniometry, Barnard (1935) discriminated skulls from four periods of Egyptian history on the basis of seven craniometric measurements on the skulls. In agriculture, Brier et al. (1940) discriminated between ewes to be kept or not, for breeding on the basis of scores on body type and weight; and Panse (1946), on hens, on the basis of egg production and other observed characteristics. In economics, Durand (1941) discriminated between good and bad credit risks, and Tintner (1946) separated consumer and producer goods on the basis of observations of prices and price cycles. Even in literature, Yardi (1946) classified plays into three creative periods of Shakespeare on the basis of the number of redundant final syllables, full split lines, unsplit lines with pauses, and speech lines. In all these studies, the applications of the technique followed a similar procedure. The groups or classes are described, the linear function, computed, and the test of significance, made. In some studies, the relative discriminatory value of the different variables was evaluated; in others, the assumptions underlying the linear discriminant function were tested.

Tatsouka and Tiedeman (1954) reported that despite the extensive theoretical developments in discriminant analysis, this technique is virtually unused in education and psychology. Illustrative applications of discriminant analysis were made by Travers (1939), Garrett (1943), and Wherry (1947). In education, particularly in the area of educational guidance, the work of Bryan (1950), Christensen (1952), Tiedeman and Sternberg (1952), and Tiedeman and Bryan (1954) are excellent examples. Bicknell (1950) used an extension of the discriminant function to formulate an equation for predicting survival-attrition tendency among entering freshmen in the Division of Agriculture at the Iowa State College. The predicted

tendency indicated by the discriminant function was converted into probabilities from tables of the normal curve.

Ahmann (1955) applied the technique in the classification of students in the New York State College of Agriculture at Cornell University, dividing them into two groups for purposes of counseling on the basis of test scores on the Ohio State University Psychological Test, The Cornell General Mathematics Test, the Cooperative Reading Comprehension Test, the Cooperative General Achievement Test, and the high school grade-point average. Although the discriminant function obtained was non-significant, it did not deprecate the usefulness of the technique, but indicated the need for other more discriminating measurements.

Tatsouka (1956) developed, on a theoretical basis, the "joint-probability of membership and success in a given group." The method, which combined the information from multiple regression analysis and discriminant analysis into one index number, proposes that in guidance work, an individual should be urged to consider entering that group for which his joint probability of membership is larger. In checking and comparing predictions with the actual choice, the investigator found that the agreement between the predictions of the joint-probability index with actual choice was rather poor. These last two studies are the only ones reported since the symposium on discriminant analysis reported by Tiedeman *et al.* (1951), was held at Harvard University. Certainly, the usefulness of the technique in educational research has not been fully exploited.

MATERIALS AND PROCEDURES

The dependent variable. The basic assumption indicated to underlie the separation problem is that there pre-exists a dichotomous situation which serves as the dependent variable and thus needs to be defined carefully.

In the College of Agriculture of The Pennsylvania State University, the *a priori* dichotomy is composed of officially defined programs of course work. There are three such programs, A, B, C, but C was not included in this study because of the extremely small number of students enrolled in it. The elimination of program C created the assumed dichotomy, which marked the point of departure for the study.

The catalog of The Pennsylvania State University defined the dichotomy in the freshman year as follows:

Program A is for all students planning to major in Agricultural and Biological Chemistry, Agronomy, Bacteriology, Botany and Plant Pathology, Medical Technology, Poultry Husbandry, Pre-Veterinary, or Zoology and Entomology; and for those students in Agricultural Journalism, Animal Husbandry, Dairy Science, General Agriculture, or Horticulture who desire a science background or who plan to pursue graduate work for an advanced degree.

Fall Semester	*Credits*	*Spring Semester*	*Credits*
Ag. 1, Survey of Agriculture	1	Bot. 2, General Botany (4), or	
Bot. 1, General Botany (4), or		Zool. 25 or 26, General Zoology (3)	4-3
Zool. 25, General Zoology (3)	4-3	Chem. 2, General Chemistry and	
Chem. 1, General Chemistry	5	Qualitative Analysis	5
Eng. Comp, Composition and		Eng. Comp. 5, Exposition	3
Rhetoric	3	Math. 42,[a] Differential Calculus	4
Math. 41,[a] Analytic Geometry	4	Phys. Ed. 2	1
Phys. Ed. 1	1	Army 2 or Air 2	1½
Army 1 or Air 1	1½		
	19½-18½		18½-17½

[a] Students may schedule mathematics courses other than Math. 41 and 42 with the consent of the head of the major department.

Program B is for all students planning to major in Agricultural Economics and Rural Sociology, Agricultural Education, Agricultural Journalism, Animal Husbandry, Dairy Science, General Agriculture, and Horticulture, except those primarily interested in the scientific phase of or who expect to pursue graduate study in, the last five curricula mentioned. Such students should schedule program A.

Fall Semester	*Credits*	*Spring Semester*	*Credits*
Ag. 1, Survey of Agriculture	1	Bot. 2,[a] General Botany (4), or	
Bot. 1,[a] General Botany (4), or		entomology or zoology elective	
Bot. 27, The Principles of Biology Illustrated with Plant		(3)	4-3
Materials (3)	4-3	Chem. 2, General Chemistry and	
Chem. 1, General Chemistry (5),		Qualitative Analysis (5), or	
or Chem. 3, Essentials of		Chem. 4, Essentials of Chemistry (3)	5-3
Chemistry (3)	5-3	Eng. Comp. 5, Exposition	3
Eng. Comp. 1, Composition and		Elective	3-6
Rhetoric	3	Phys. Ed. 2	1
Elective	3-5	Army 2 or Air 2	1½
Phys. Ed. 1	1		17½
Army 1 or Air 1	1½		
	18½-17½		

[a] Students considering a major in Horticulture should elect Bot. 1 in the fall semester and Bot. 2 in the spring semester.

Several areas of concentration listed under both programs of study were considered in drawing the students to compose the samples representing the two programs. A student's identification with any of the two programs was based not only on the indicated area of concentration but also on particular subjects taken. The subjects specially useful in identifying the program of a student were Chemistry 1 and 2, and Mathematics 41 and 42. In program A, Chemistry 1 and 2 carry five credits each, while in program B, two other chemistry subjects with three credits each, may be substituted for the five-credit chemistry subjects. In program A, eight credits of mathematics are required while in program B, none is required. The dichotomy is not rigidly defined. For purposes of this study, program A was defined as the science-oriented group and program B, the general and applied group.

As this study progressed, two subgroups were recognized in program A, namely, (1) the Biological Science group, composed of students whose fields of concentration were in Agricultural and Biological Chemistry, Botany and Plant Pathology, Bacteriology, Medical Technology, Pre-Veterinary, and Zoology and Entomology; and (2) the Agricultural Science group, composed of students whose fields of concentration were in Agronomy, Poultry, Agricultural Journalism, Animal Husbandry, Dairy Science, General Agriculture and Horticulture; and who desired a science background or who planned to pursue graduate work for an advanced degree. These two subgroups in program A created the dichotomy used as the dependent variable for a subsidiary separation problem.

The three subgroups in program B were: (1) the Agricultural Economic-Rural Sociology group, (2) the Agricultural Education group, and (3) the Others group, composed of students whose fields of concentration were in Agricultural Journalism, Animal Husbandry, Dairy Science, General Agriculture, and Horticulture, but who were not primarily interested in the scientific phase of, or who did not expect to pursue graduate study in these areas. These recognized subgroups enabled the investigator to pose three other subsidiary separation problems using the following dichotomies as dependent variables: Agricultural Economics-Rural Sociology and Agricultural Education; Agricultural Economics-Rural Sociology and Others; and Agricultural Education and Others.

The subsidiary separations of the two major programs (A and B) into more specific categories provided equal, if not more interesting and important information, than the major separations.

The independent variables. The assumed major dichotomy in course work (programs A and B), and the recognized dichotomies within the two programs were established on the basis of certain arbitrarily selected factors. This investigator hoped to find factors other than those used to establish the *a priori* dichotomies, and to determine whether or not a linear combination of these factors could bring about maximum separation. These other factors constitute the independent variables in this study. Certain objective measurements on students entering the College of Agriculture of The Pennsylvania State University were found to be available in the Counseling Division of the University. These measurements were the high school graduation rank, aptitude test scores from the Moore-Castore Aptitude Test, personality trait scores from the Bernreuter Personality Inventory, and vocational interest scores from the Strong Vocational Interest Blank for Men. These scores were compiled during the freshmen orientation week. It was decided to use them as bases upon which separation would be attempted. Table 1 shows the symbol used for each measurement, the identification of each and the instruments used in their measurement.

TABLE 1.—*Symbol, identification and measuring instrument used for each of the independent variables*

VARIABLE	IDENTIFICATION	MEASURING INSTRUMENT
X_1	High school graduation rank	
X_2	3—Part total	Moore-Castore Aptitude Test
X_3	4—Part total	" " "
X_4	Stability	Bernreuter Personality Inventory
X_5	Self-sufficiency	" " "
X_6	Dominance-submission	" " "
X_7	Science and Engineering group interest	Strong Vocational Interest Blank for Men
X_8	Chemical interest	" " " " " "
X_9	Engineering interest	" " " " " "
X_{10}	Farmer interest	" " " " " "
X_{11}	Math.-Science teacher interest	" " " " " "
X_{12}	Social service group interest	" " " " " "
X_{13}	Personnel manager interest	" " " " " "
X_{14}	Social-science teacher interest	" " " " " "
X_{15}	Business group interest	" " " " " "
X_{16}	Sales group interest	" " " " " "

Except for variables X_1, X_2 and X_3, which were reported in numerical terms, all were originally reported in letter scores. How-

ever, the Counseling Division assigned numerical values to the letter scores. These numerical values were used in the present study. Explanations of the scores for each variable follow.

The high school graduation rank (X_1) was reported in terms of fifths. The numerical value of *1* was assigned to the highest fifth, and *5*, to the lowest fifth. The intervening numerical values *2*, *3* and *4* corresponded to the second highest, middle, and second lowest fifths, respectively.

The 3-part (X_2) and 4-part (X_3) total scores on the Moore-Castore Aptitude Test were reported as raw scores and were used as such in the study.

Letter scores from the Bernreuter Personality Inventory ranged from A to J, with A assigned a numerical value of *0* and J, a value of *9*. The intervening letter scores B, C, D, E, F, G, H, and I were assigned numerical values of *1*, *2*, *3*, *4*, *5*, *6*, *7*, and *8*, respectively. Table 2 will help to interpret the meaning of the scores for each of the three variables (X_4, X_5 and X_7) obtained from the Bernreuter Personality Inventory.

TABLE 2.—*Meanings of scores made on the Bernreuter personality inventory* [a]

Letter score	A	B-C	D-E-F-G	H-I	J
Numerical value	0	1-2	3-4-5-6	7-8	9
X_4 (Stability)	Stable	Somewhat stable	Normal	Somewhat easily upset	Easily upset
X_5 (Self-sufficiency)	Self-sufficient	Somewhat self-sufficient	Normal	Somewhat dependent	Dependent
X_6 (Dominance-Submission)	Dominant	Somewhat dominant	Normal	Somewhat submissive	Submissive

[a] From the "Traits and Interest Card" of the Student Advisory Service, The Pennsylvania State University. (This card was also used as source of the information for the scores on the Strong Vocational Interest Inventory).

The scores from the Strong Vocational Interest Blank For Men had the following categories: A, B+, B, B−, C+ and C. These letter scores were assigned numerical values of *4*, *5*, *6*, *7*, *8*, and *9*, respectively. An "A" or *4* score indicates that the individual had answered the blank in a manner typical of the successful men in that vocation. A "C" or *9* score indicates that the individual had little in common with the successful men in the field, is so far as

interests are concerned. A "B" or *6* score indicates an intermediate degree of interest. The vocations in each division of the blank have a great deal in common. A "Group" score indicates how much interest an individual had in common with the men in all of the vocations in a division of the blank.

For purposes of this study, all these measurements and the instruments used in taking them were assumed to be valid. Furthermore, as was stated previously, the present study might provide evidence of the validity of the measurements and instruments in so far as their discriminatory qualities are concerned.

The preliminary hypothesis. Stated in null form, the preliminary hypothesis is that there are no significant differences in the means of the two groups of students (programs A and B students) on the 16 different independent variables. This hypothesis was postulated to serve as a guide in the development of the study especially in the use of the independent variables to derive the discriminant functions for maximum separations. However, the testing of the hypothesis could not be conclusive because the independent variables were considered individually rather than in combination with one another. Also, the decision to relate the technique of discriminant analysis to regression analysis as programmed in PENNSTAC (The Penn State Automatic Computer), which provides in the computations for the elimination of insignificant variables, limited the value of testing this preliminary hypothesis.

The major and subsidiary hypotheses. To facilitate testing for significance, the major and subsidiary hypotheses were stated in null form.

The major hypothesis: There is no significant separation between the group of students who followed program A course work, and those who followed program B.

The recognition of subgroups within programs A and B in the major separation problem brought about the postulation of four subsidiary hypotheses, stated also in null form.

Subsidiary hypothesis one: There is no significant separation between the Biological Science group and the Agricultural Science group in program A.

Subsidiary hypothesis two: There is no significant separation between the Agricultural Economics-Rural Sociology group and the Agricultural Education group in program B.

Subsidiary hypothesis three: There is no significant separation between the Agricultural Economics-Rural Sociology group and the Others group excluding the Agricultural Education group in program B.

Subsidiary hypothesis four: There is no significant separation between the Agricultural Education group and the Others group excluding the Agricultural Economics-Rural Sociology group in program B.

In postulating the major and subsidiary hypotheses, it was assumed that there exists a linear combination of the independent variables and that these same variables have additive effects in classifying the students into one or the other of two categories or groups. These assumptions together with that mentioned in the statement of the problem were necessary for the application of the statistical technique that was planned for the study. However, it should be noted at this point that some departures from these assumptions may not seriously impair the usefulness of the technique.

The samples and their selection. The members of the classes of 1956, 1957, and 1958 of the College of Agriculture, The Pennsylvania State University, numbering 558, provided the samples to represent the two groups in the *a priori* dichotomy. The requirements made on each individual included in the samples were: (1) Male, (2) Identification with either program of course work based on whether or not the student enrolled in any field of concentration, and was able to graduate from such, and (3) A complete record of the set of measurements involved in this study for each student included.

The original number of 558 individuals was separated on the basis of the *a priori* dichotomy into program A and program B, with 163 individuals classified in the former, and 395 in the latter. Of the 163 in program A, 110 satisfied the requirements. For computational convenience, an equal number (110) was decided as sample for program B. These 110 individuals were drawn from the program B group (395) by a system of continuous sampling without replacement until the required number was attained. Table 3 shows the distribution of the samples by year and by curriculum.

The samples for the testing of the first subsidiary hypothesis were the two recognized groups which had 47 individuals in the Bio-

TABLE 3.—*Distribution of samples by program of course work, year, and field of concentration*

	PROGRAM A				PROGRAM B				GRAND TOTAL
	1956	1957	1958	Total	1956	1957	1958	Total	
Agricultural Biochemistry	3	7	6	16	—	—	—	0	16
Agronomy	13	11	7	31	—	—	—	0	31
Animal Husbandry	1	6	2	9	9	3	6	18	27
Dairy Science	1	1	1	3	7	6	7	20	23
Horticulture	2	—	6	8	3	7	2	12	20
Poultry	7	1	2	10	—	—	—	0	10
Agricultural Journalism	—	—	1	1	—	—	1	1	2
General Agriculture	—	1	—	1	1	3	6	10	11
Pre-Veterinary Science	5	—	7	12	—	—	—	0	12
Zoology-Entomology	1	5	8	14	—	—	—	0	14
Bacteriology	1	2	2	5	—	—	—	0	5
Agricultural Economics & Rural Sociology	—	—	—	0	5	4	3	12	12
Agricultural Education	—	—	—	0	10	14	13	37	37
Total	34	34	42	110	35	37	38	110	220

logical Science group, and 63 in the Agricultural Science group. Thus all of those in program A were included in the separation.

For testing the second, third, and fourth subsidiary hypotheses, the sample for program B was separated into three subgroups namely, the Africultural Economics-Rural Sociology group of which there were 12 individuals; the Agricultural Education group, 37 individuals; and the Others group, 61 individuals. The Agricultural Economics-Rural Sociology group was increased to 31, and the Agricultural Education group to 66, by drawing from the original program B group of 395 members all those individuals who satisfied the requirements mentioned above, and whose fields of concentration were in the two areas covered by the two subgroups in question.

Collection and preparation of the data. After a careful examination of the records of the Counseling Division for the academic years 1952, 1953, and 1954 (the graduates of 1956, 1957, and 1958 were involved), the measurements for each individual were transferred to work sheets. These measurements were in terms of numerical values. There was no further treatment of these data except in preparing them for computation in the automatic computer.

In testing the preliminary hypothesis, the data were treated in the form in which they were collected. However, in the analysis for testing the major and subsidiary hypotheses, the data were coded and scaled to conform with the operational requiremments of PENNSTAC. Special code sheets were used. Each individual with his set of measurements was considered a replication. The measurements were so scaled such that the sums and sums of the squares for each of the 16 independent variables, after scaling, were less than 100 to avoid overflow during the computations in PENNSTAC. From an examination of the data and with a knowledge of the number of replications, the scaling factor for each variable was estimated to be 10^{-2} for all of the variables except X_2 and X_3, for which a scaling factor of 10^{-3} was estimated. Applying the scaling factor estimates to the first replication, the data in the code sheet appeared as decimal values (appendix A). The last value is a check for accuracy in coding and scaling. The first column of the same code sheet is a set of instructions for computation. All the data, after being entered into the code sheets, were punched on the imput tape, preparatory to feeding into the computer.

Statistical procedures. Simple analysis of variance was used for testing the preliminary hypothesis. The test of significance was at the five per cent level.

In testing the major and subsidiary hypotheses, the technique of discriminant analysis was employed. The criterion in discriminant analysis is qualitative rather than quantitative. Kendall (1946) introduced a formal variate y for the two classes in a dichotomy. He defined the variate as follows: If there are n_1 members in one class and n_2 in the other, the variate y assigned to the two classes respectively is:

$$\frac{n_2}{n_1 + n_2}, \frac{-n_1}{n_1 + n_2}.$$

Thus the mean of y for the whole sample is *0*. With the foregoing relationship, it was then possible to proceed in the statistical treatment and computations in testing the major and subsidiary hypotheses in the same way as in regression analysis. PENNSTAC was programmed for regression analysis. The introduction of the needed variate y for each of the two classes in the five sets of dichotomy involved in the major and subsidiary hypotheses enabled the investigator to do discriminant analysis with the use of the automatic computer.

The elimination of insignificant variables is an interesting feature of the statistical procedure. F—ratios were used in a manner quite different from their conventional use in testing significance. In code sheet 112 (see appendix A), variables X_1, X_3, X_7, and X_{12} were retained regardless of the outcome of the elimination procedure.

The output medium [2] of PENNSTAC, a printed tape, had four blocks of values: the first being the sums, the sums of squares and crossproducts; the second, the correlation matrix; the third, the inverse of the correlation matrix; and the fourth, a successive definition of the discriminant function with the residual variance (utilized in the analysis of discriminant function as suggested by Kendall).

[2] The complete printed output tape for each of the separation problems in this study is on file in the Department of Agricultural Education, Pennsylvania State University and in the Department of Agricultural Education, University of the Philippines.

Fisher's (1950) test of significance for R^2 was put in the form of Snedecor F-test as follows:

$$F = \frac{R^2 \ (N-p-1).}{p \ (1-R^2)}$$

Here, p is the number of independent variables, N−p−1 stands for the greater degrees of freedom and p, the lesser degrees of freedom. From the PENNSTAC computations, the residual variance subtracted from the total variance 1, gave the sum of squares, R^2, for the discriminant function considered as the "Between" sum of squares. The residual variance was considered as the "Within" sum of squares. The testing of significance of the discriminant function can be made in a manner identical to the procedure in the analysis of variance.

In the use of the technique of discriminant analysis, it was assumed that any measurement had the same variance for one group of the dichotomy as for the other, differing only as to the means; and that these measurements had simultaneous normal distributions.

Determination of the critical score and validation of the discriminant function. To validate and test the efficiency of the major discriminant function and to determine its use for prediction, a critical score for determining the group to which an individual belongs, was determined. This critical score was found through the procedure suggested by Wert *et al.* (1954). The discriminant function was solved twice, once by inserting the mean values of the variables for one group, and then the mean values of the same variables for the other group. The critical score was considered to lie midway between the two y-values found in the two insertions. The group to which an individual belongs is determined by comparing whether the computed y-value of such an individual is less or greater than the critical score.

After the critical score was determined, the data for the validation were collected. The validation group was composed of Class 1959. The y-value for each member of the group was computed with the use of the discriminant function. The proportion of the validation group properly classified by the discriminant function was considered to be a measure of the predictive usefulness of the function. (The validation group is a sample different from the group samples used in deriving the discriminant function and therefore, validation and measurement of the predictive usefulness of the function was

reasonably rigorous). The predictions were tested for discrepancy from the actual observations by chi square analysis, which showed whether or not the predictions were highly associated with the actual classifications, and whether or not the discriminant function was reasonably efficient for purposes of prediction.

Only the critical score for the major separation was determined, and only the major discriminant function was validated, using the members of class 1959. For lack of adequate data, determinations for validity were not made for the separations within the major groups. All the discriminant functions for both the major and subsidiary separations were, however, tested for significance at the five per cent level.

Separation beyond college. To gather evidence from which to adduce proof that separation in course-work programs in college was carried on to the graduates' occupational pursuits, and to collect data pertaining to the use in counselling of the independent variables involved in this study, a survey of the occupations of the individuals included in the sample for the major separation problem was made.

RESULTS AND DISCUSSION

Preliminary analysis. The preliminary hypothesis of no significant difference in the means of the measurements for the two major groups of students on the 16 different independent variables was postulated in order to determine which of these variables taken independently would show promise of being useful in the separation problems involved in the study. However, as was pointed out earlier, the results of the preliminary analysis should be considered inconclusive because the variables were analyzed independently and therefore possible inter-relationships between the variables were not taken into account. Furthermore, with PENNSTAC to do the computations which considered combinations of variables and which included the elimination of the insignificant ones, the preliminary analysis involving the application of simple analysis of variance of the scores of the two groups of students on the 16 different independent variables could have been dispensed with. Nevertheless, the preliminary analysis was still considered useful in that its results could be compared with the results of PENNSTAC computations to show the effects of inter-relationships of variables in multivariate analysis. Variables may prove to be insignificant when

considered individually but may prove to be significant if considered in combination, or *vice versa*.

For purposes of discussion of the results of the analysis of variance, table 4 shows the means of the two groups on each of the

TABLE 4.—*Mean group scores of students in programs A and B and the significance of the differences in means on 16 different independent variables*

VARIABLE	PROGRAM A Group mean	PROGRAM B Group mean	GRAND DIFFERENCE Mean	DIFFERENCE MA – MB	COMPUTED F-VALUE
X_1	1.81	2.31	2.06	–0.50	14.91 * [a]
X_2	103.84	90.45	97.15	13.39	21.75 *
X_3	127.98	109.64	118.81	18.34	33.35 *
X_4	3.79	3.95	3.87	–0.16	0.03
X_5	5.05	5.85	5.45	–0.80	12.15 *
X_6	4.75	4.83	4.79	–0.08	0.19
X_7	5.55	7.25	6.40	–1.70	70.88 *
X_8	6.08	7.68	6.88	–1.60	55.59 *
X_9	6.30	7.80	7.05	–1.50	60.55 *
X_{10}	4.57	4.42	4.50	0.15	1.54
X_{11}	5.65	5.91	5.78	–0.26	1.42
X_{12}	6.92	5.85	6.39	1.07	24.49 *
X_{13}	8.34	7.43	8.10	0.91	7.12 *
X_{14}	7.84	6.45	7.13	1.39	43.47 *
X_{15}	7.55	6.69	7.12	0.86	19.16 *
X_{16}	7.25	6.66	7.96	0.59	1.06

[a] In the figures with asterisks, the value of F must equal or exceed 2.89 to be significant at the 5 per cent level with 1 and 218 degrees of freedom.

variables, the grand mean, mean differences and their significance. The differences in means were found by subtracting the mean for the program B students from the mean for the program A students. This decision was entirely arbitrary and it would have been equally satisfactory if the procedure were reversed. However, care must be observed in interpreting the results in this preliminary analysis, and in the subsequent analyses for maximum separation because of the differences in the interpretation of the scores on the different variables.

In 11 out of the 16 independent variables involved in the study, differences in means of the two groups of students were not due to chance. Evidence indicates that program A students had definitely higher graduation ranks (X_1), and aptitude scores (X_2 and X_3) than program B students. Regarding personality traits (X_4, X_5 and X_6), there were no significant differences in the scores of the

two groups on stability (X_4) and dominance-submission (X_6), but on self-sufficiency (X_5), program B students scored significantly higher than program A students.

The scores of the program A students were significantly higher on science and engineering interests (X_7, X_8 and X_9) than those of the program B students. It was suggested that the group of students in program A be designated as the science-oriented group, and evidence appears to justify such action.

Two practical interest scores (X_{10} and X_{11}) were included in the study. There is evidence which indicates that on the basis of either of these variables, program A students cannot be definitely differentiated from program B students. The variables designated as X_{10} and X_{11} were farmer and mathematics-physical science teacher interests, respectively. The inclusion of these interests in only one group, the practical interest group, in the measurement instrument (Strong Vocational Interest Inventory for Men) was not definitely confirmed. Strong (1945) stated that some data confirmed the grouping while some suggested that these interests should not be grouped together. Although the differences in means were not significant, it is interesting to note that program B students scored slightly higher than the Program A students on farmer interest (X_{10}) while the reverse is true in the case of the mathematics-physical science teacher interest.

The social service group interest scores (X_{12}), the personnel manager interest scores (X_{13}) and the social-science teacher interest scores (X_{14}) of the program B students were significantly higher than those of the program A students. The findings in these variables might be considered as evidence to justify the suggested designation of the program B group as the general and applied student group.

The business group interest scores (X_{15}) of the program B students were significantly higher than those of the program A students. However, no significant difference was found on the sales interest group average scores. It must be recalled that program B includes students whose fields of concentration were in Agricultural Economics-Rural Sociology and this may explain why the program B group showed significantly higher scores on the business interest group. However, the finding of the analysis of the scores for the business group interest (X_{15}) does not explain the finding in the sales group

interest (X_{16}). It is believed that the explanation for this situation can be found in the different interests included in the sales group interest and in the business group interest. The interests included under the sales group were sales manager interest, real estate salesman interest, and life insurance interest, those in the business interest group were accountant interest, office man interest, purchasing agent interest, and banker interest. It is obvious that the sales group differs from the business group in that the former is self-centered and wholly of one kind of interest—that of salesmanship for personal gains, while in the latter the interests are those related to the operation of a business entity, which is more group or organization-centered. It was natural therefore, that the program B students made significantly higher scores on the business interest group than the program A students. But no significant difference should be expected between the two groups on the sales group interest scores because all are interested in personal gains.

The analysis of variance indicated that there were variables on which scores of the two groups of students showed significant differences. These variables were X_1, X_2, X_3, X_5, X_7, X_8, X_9, X_{11}, X_{12}, X_{13}, and X_{15}. The analysis of variance of the scores of the two groups of students on variables X_4, X_6, X_{10}, X_{14}, and X_{16} showed no significant differences. The tests of significance provided evidence to reject the null hypothesis of no differences on 11 variables, and of failure to reject the same hypothesis on five variables. The variables were not considered simultaneously and possible inter-relationships were not taken into account. Thus neither a critical score nor a linear combination of the scores to separate the two groups of students could be available from the analysis. However, these results were still important since they provided information which guided the investigator in making certain decisions as the study progressed. It would be also interesting to compare the results of the preliminary analysis with the results of the discriminant analysis in the different separation problems.

Separation of program A students from program B students. The major hypothesis of this study is that there is no significant discrimination between students who enter into and are able to graduate from any curriculum under program A course work and students who enter into and are able to graduate from any curriculum under program B course work on the basis of high school graduation ranks, aptitude test scores, personality traits and vocational interests.

In the preliminary analysis, it was found that the differences in scores of the two groups of students were not due to chance in 11 out of the 16 characteristics or variables. But it must be remembered that the preliminary analysis did not take into account interrelationships between the variables. It could therefore be expected that the variables which did not show significant differences in the preliminary analysis might indicate significant differences when considered in combination with other variables. The reverse is also as much a possibility, that is, the variables which showed significant differences might not indicate significant differences when considered in combination with other variables. The decision to use PENNSTAC, the digital computer, to do the computations including the elimination of insignificant variables simplified the situation. The elimination procedure in the computer proceeded on the size of the ratio of the square of the coefficient of the variable to the square of the standard deviation of the coefficient of the same variable (b_j^2/s_j^2). When this ratio is the smallest in the entire set of b^2/s_b^2 at any stage of the elimination procedure, then variable j is a candidate for elimination. Thus it can be seen that elimination proceeds without consideration of the importance of the variable to the problem being studied. Fortunately, a provision can be introduced into the computations so that certain variables can be retained whatever happens in the elimination procedure. In this study, the investigator considered variables X_1, X_3, X_7 and X_{12} to be the most logical variables to be retained in the discriminant function which is the end product of discriminant analysis. Variable X_1 (High School Graduation Rank) was selected to be retained because of its proven usefulness in prediction studies; X_3 (4-Part Total, Aptitude Test Score), because it is indicative of the total scholastic capabilities of an individual; X_7 (Science and Engineering Group Interest Score) because it indicates how much interest an individual has in common with men whose occupations are included in the science and engineering fields; and X_{12} (Social Service Group Interest Score), because like X_7, it indicates how much interest an individual has in common with men whose occupations are included in the field of social service. Programs A and B do not represent any single field of concentration but rather several fields. It was therefore logical for the investigator to have selected to be retained those variables which do not represent scores of specific vocational interests.

Preparatory to scaling and coding it was necessary to manufacture the y-variate to serve as the criterion for the two categories or programs of course work. The use of the formulae suggested by Kendall yielded the y-variate for programs A and B as $+0.5$ and -0.5, respectively. After this operation, all the data including the manufactured y-variates were scaled, coded and punched into the input tape of PENNSTAC. Automatic computations in PENNSTAC resulted in a printed output which contained a series of four blocks of values. Only the second and the last blocks were directly useful to the present study. The second block included the sums of squares of deviations from the mean for each of the 17 variables including the manufactured y-variate. These values are followed by the diagonal and post-diagonal part of the matrix of simple correlation coefficients. A portion of this block with appropriate annotations in parentheses is shown in appendix B. The discriminant function was derived directly from the correlation matrix rather than from the sums, sums of squares and crossproducts given in the first block. This was possible because all the variables were scaled by the computer in the following manner: If X be one of the variables, $\overline{X}$ its mean, s its standard deviation, then $X^1 = \frac{X-\overline{X}}{\sqrt{N}\ s}$, where N is the number of observations; X^1 is the scaled variable used in the calculations and this allows the correlation matrix to be used instead of the sums, sums of squares and crossproduct matrix.

The last block consists of three columns of values. The first column defined the variables involved; the second column, the variable eliminated followed by the coefficients of the remaining variables, and the third column, the residual variance for each combination of variables followed by the variance of each of the coefficients of the variables in the combination. A portion of this block with annotations in parenthesis is shown in appendix B. This block is the most important portion of the PENNSTAC output in so far as the present study is concerned. The discriminant functions beginning with the one containing all the variables, and each of the subsequent functions wherein insignificant variables were eliminated, were defined. An examination of this block shows that PENNSTAC computations found variables X_{13}, X_{16}, X_4, X_{15}, X_6, X_9, X_8, X_2, X_{10}, X_5, and X_{11} as insignificant in the linear combination and hence

were eliminated in the order they are mentioned. The results of the elimination procedure by PENNSTAC calculations differ from the results of the analysis of variance shown in table 4. In addition to the four variables (X_1, X_3, X_7 and X_{12}) which were selected to be retained, X_{14} was indicated by PENNSTAC computations to be a significant variable in the linear combination. The portion of the block which defined the final equation is:

00000000012	00000000011	00065240110
–00100000000	–00013674994	00000337833
–00300000000	00022006585	00000355652
–00700000000	–00030551580	00000474062
–01200000000	00000660240	00000741720
–01400000000	00020114929	00000834208

The final equation was the twelfth equation where X_{11} was eliminated, leaving a residual variance of 0.6524. The discriminant function is formed as follows:

$$y = -0.1367X_1 + 0.2201X_3 - 0.3055X_7 + 0.0066X_{12} + 0.2011X_{14}$$

The above function is in standard units and is interpreted in a manner similar to that of the multiple regression equation. Thus the y-value in standard units is reduced by 0.1367 for every unit of X_1; increased by 0.2201 for every unit of X_3; reduced by 0.3055 for every unit of X_7; increased by 0.0066 for every unit of X_{12}; and increased by 0.2011 for every unit of X_{14}. By the use of the y-equation it is possible to compute a y-score for any individual on whom measurements of the five variables (X_1, X_3, X_7, X_{12} and X_{14}) are available.

To determine whether or not the function achieved more discrimination than would result from chance, a test of significance was made. Since in the PENNSTAC calculations the dependent variable y was scaled to the form, $y' = \frac{Y - \bar{Y}}{\sqrt{N}\, s}$, the total sum of squares of the y's is equal to 1, or the total variance 1 is equal to the sum of the variance accounted for by the discriminant function (R^2) and the residual variance. The residual variance was given in the PENNSTAC output as 0.6524, therefore the variance due to the function is 0.3476. By supplying the appropriate degrees of freedom, the mean squares were computed and the analysis of discrimina-

tion proceeded as in the analysis of variance. Table 5 shows the analysis.

TABLE 5.—*Analysis of the discriminant function*

SOURCE OF VARIATION	d.f.	SUM OF SQUARES	MEAN SQUARE	F
Discriminant function	5	0.3476	0.0695	23.2
Residual variance	214	0.6524	0.0030	
Total	219	1.0000		

The value of F must equal or exceed 2.26 to be significant at the five per cent level with 5 and 214 degrees of freedom. Since the computed value of F is 23.2, the function is highly significant. It achieved more discrimination between the program A students and the program B students than would result from chance.

Determination of the critical score and validation of the discriminant function. A critical score for determining the group to which an individual belongs was found by solving the discriminant function twice, once by inserting the mean values of the variables for the program A students and then the mean values of the same variables for the program B students. The midpoint between the two y-values found in solving the discriminant function twice was designated as the critical score.

The results of the calculations are:

y-Value for Program A = 27.8489
y-Value for Program B = 22.9339
Midpoint = 25.3913

The critical score may also be considered as the mean y-value of all the students.

The critical score of 25.3913 was the reference point for classifying students included in the validation group. The individual y-values of the students were computed and compared with the critical score. When the y-value was less than the critical score the student was classified as belonging to program B; when it was greater than the critical score the student was classified as belonging to program A. The proportion of the validation group that was properly classified was considered as an important value to measure the usefulness of the discriminant function. Table 6 shows this proportion.

TABLE 6.—*Classification of the validation group with the use of the discriminant function*

PROGRAM	PROGRAM A		PROGRAM B		TOTAL	
	No.	Per cent	No.	Per cent	No.	Per cent
Correctly classified	22	84.5	47	65.3	69	70.0
Wrongly classified	4	15.5	25	34.7	29	30.0
Total	26	100.0	72	100.0	98	100.0

From the table, it can be seen that the discriminant function classified the students in the validation group at the rate of seven correct classifications for every three wrong classifications.

A geometrical portrayal of the individual y-distributions of the students in the validation group is shown in figure 2. The individual y-values were computed by using the discriminant function found

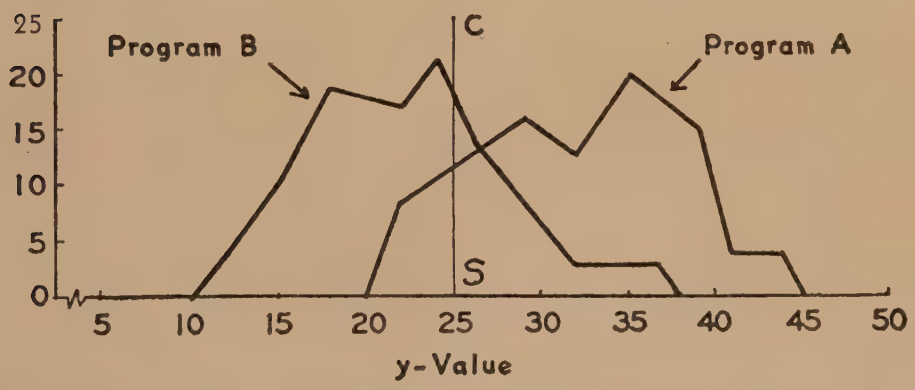

Fig. 2.—Distribution of the y-values of the students in the validation group.

in the major separation analysis. The ordinate CS erected at the y-value of about 25.39 represents the critical score. The frequencies for the program A group were multiplied by the ratio 72/26 in order to make the total area under each curve equal. It will be noted that the dividing line CS is near the point where the curves intersect. The point where the two curves intersect is the position where maximum separation could be obtained. If the dividing line passes farther away on either side of the point of intersection, more of the individuals in either group would be misclassified. As noted in table 6, the proportion properly classified is about 70 per cent.

The dividing line would not have passed so close to the point of intersection of the two curves had not the frequencies been equalized.

Table 6 was transformed into a 2x2 contingency table and the data were treated by chi square analysis. In this analysis it was postulated that frequencies of actual classifications were not significantly associated with the classifications indicated by the discriminant function.

Computations of the data in table 7 gave a chi square value of 21.1 which is highly significant at the one per cent level with one degree of freedom. The analysis shows that the classifications with the use of the discriminant function are highly associated with actual classifications and that the discriminant function can predict with a reasonable degree of accuracy the program in which a student belongs.

TABLE 7.—*Classification of the students in the validation group*

	PROGRAM A	PROGRAM B	TOTAL
Predicted A	22	25	47
Predicted B	4	47	51
Total	26	72	98

Separation within program A. Two subgroups were recognized in program A. Thus an *a priori* dichotomy was established. The two subgroups were the Biological Science group of which 47 students were included, and the Agricultural Science group which had 63. The procedure employed in the statistical analysis was identical to the procedure used in the separation of program A students from the program B students, except that not one of the variables was chosen to be retained regardless of what happened in the elimination procedure provided for in PENNSTAC. Calculations in PENNSTAC eliminated variables X_{14}, X_8, X_6, X_{15}, X_3, X_2, X_1, X_{16}, X_4, X_5, X_{13}, X_9, X_{12}, and X_{11} as insignificant variables, in the order they are mentioned. The discriminant function that resulted was defined by equation 15:

00000000015	00000000011	00087584895
00700000000	–00028567090	00000828092
01000000000	00023919233	00000828092

Thus, $y = -0.2857X_7 + 0.2392X_{10}$.

Variable X_7 is the Science and Engineering group interest score and X_{10}, the farmer interest score. The function includes the variables which the investigator would consider to be the logical variables for discriminating between the Biological Science and the Agricultural Science groups.

Table 8 shows the direction of differences between the two subgroups of students for the variables retained in the function. The Biological Science group made significantly higher science and engineering group interest scores (X_7) but lower farmer interest scores (X_{10}) than the Agricultural Science group.

TABLE 8.—*Mean scores of the biological science group and the agricultural science group in program A on the sixteen independent variables* [a]

VARIABLE		BIOLOGICAL SCIENCE GROUP	AGRICULTURAL SCIENCE GROUP
X_1	(in fifths)	1.64	1.94
X_2	(in raw scores)	106.77	100.92
X_3	" " "	131.77	125.40
X_4	(in assigned numerical values)	4.28	3.71
X_5	" " " "	4.74	5.29
X_6	" " " "	4.81	4.75
X_7	" " " "	5.08	5.89
X_8	" " " "	5.55	6.48
X_9	" " " "	6.02	6.48
X_{10}	" " " "	4.81	4.40
X_{11}	" " " "	5.36	6.87
X_{12}	" " " "	7.02	6.84
X_{13}	" " " "	7.94	8.22
X_{14}	" " " "	7.77	7.87
X_{15}	" " " "	7.70	8.60
X_{16}	" " " "	7.47	7.09

[a] Refer to pages 159-161 for the identification of the variables and for the interpretation of the scores.

The test for significance of the discriminant function was done directly with the use of Snedecor's F-test in the following form:

$$F = \frac{R^2 \ (N - p - 1)}{p \ (1 - R^2)},$$

which is identical to the analysis of the significance of the major discriminant function shown on page 50. The residual variance from PENNSTAC calculations given above is 0.8758. Therefore $R^2 = 1 - 0.8758$, which is 0.1242.

Thus,

$$F\ 1,107 = \frac{0.1242 \times 107}{2 \times 0.8758}$$
$$= 7.51.$$

The discriminant function was highly significant. Therefore the null hypothesis that there was no significant discrimination between the Biological Science and Agricultural Science groups was rejected. There was no attempt to validate the discriminant function with the use of the data supplied by the validation group because there was a limited number of program A students in that group.

Separation within program B. Three subgroups were recognized in program B. Three sets of dichotomies were established out of the three recognized subgroups. The procedure employed in the analysis of the three dichotomies was the same as that of the analysis of the dichotomy in program A. Calculations were all done in PENNSTAC. No validation was attempted for the discriminant functions found in the discriminant analyses between subgroups in program B. The validation group was considered inadequate in size.

For reference on the direction of differences between the subgroups recognized in program B, table 9 gives the mean scores of the three subgroups for the 16 independent variables. Table 9 is useful for the interpretation of the discriminant functions which have been found to be significant in the separation analyses made between the recognized subgroups in program B.

Separation of the Agricultural Economics-Rural Sociology group from the Agricultural Education group. The first dichotomy analyzed in program B was between the Agricultural Economics-Rural Sociology group of 31 students, and the Agricultural Education group of 66 students. PENNSTAC calculations eliminated variables X_{11}, X_7, X_5, X_9, X_{14}, X_2, X_1, X_{16}, X_8, X_4, X_6, X_{10}, and X_{13} as insignificant variables, in the order they are mentioned. Three variables, X_3 (the 4-Part Total Score on the Moore-Castore Aptitude Test), X_{12} (the Social Service group interest score), and X_{15} (the Business group interest score) were found significant. The discriminant function was defined thus:

$$y = 0.4007X_3 + 0.3077X_{12} - 0.2646X_{15}$$

The discriminant function shows that the Agricultural Economics-Rural Sociology group made significantly higher 4-part total scores (X_3) on the Moore Castore Aptitude Test, and Business group

interest scores (X_{15}) than the Agricultural Education group. However, the latter group made significantly higher Social Service group interest scores (X_{12}) that the former group (table 9).

TABLE 9.—*Mean scores of the agricultural economics rural sociology group, the agricultural education group, and the others group in program B on the sixteen independent variables* [a]

VARIABLE		AGRICULTURAL ECONOMICS-RURAL SOCIOLOGY GROUP	AGRICULTURAL EDUCATION GROUP	OTHERS GROUP
X_1	(in fifths)	1.74	2.12	2.33
X_2	(in raw scores)	94.90	84.42	94.59
X_3	" " "	116.87	99.95	115.79
X_4	(in assigned numerical values)	4.13	3.83	4.05
X_5	" " " "	5.45	5.68	5.67
X_6	" " " "	4.55	4.69	4.84
X_7	" " " "	6.65	7.18	7.23
X_8	" " " "	7.13	7.64	7.74
X_9	" " " "	7.00	7.65	7.84
X_{10}	" " " "	4.39	4.56	4.54
X_{11}	" " " "	5.81	5.73	6.25
X_{12}	" " " "	6.55	5.73	5.90
X_{13}	" " " "	7.74	7.88	7.38
X_{14}	" " " "	7.10	6.52	6.51
X_{15}	" " " "	6.26	6.74	6.93
X_{16}	" " " "	6.61	6.72	6.52

[a] Refer to pages 159-161 for the identification of the variables and for the interpretation of the scores.

When the function was tested, an F-value of 10.82 was found to be significant at the five per cent level with 1 and 95 degrees of freedom. Evidence showed that the Agricultural Economics-Rural Sociology group could be separated from the Agricultural Education group on the basis of the linear combination of variables X_3, X_{12} and X_{15}.

Separation of the Agricultural Economics-Rural Sociology group and the Others group excluding the Agricultural Education group in program B. In the Others group excluding the Agricultural Education group, there were 61 students included. The Agricultural Economics-Rural Sociology group was again composed of 31 students. PENNSTAC calculations yielded the discriminant function: $y = -0.2625X_1$. All the variables except X_1 were found to be insignificant and hence were eliminated in the calculations of PENN-

STAC. The Agricultural Economics-Rural Sociology group had significantly higher high school graduation ranks than the Others group.

When tested for significance, the single-term function gave an F-value of 6.59 which was found to be significant at the five per cent level with 1 and 90 degrees of freedom. On the basis of the high school graduation rank alone, the Agricultural Economics-Rural Sociology group can be separated from the Others group excluding the Agricultural Education group in program B.

Separation of the Agricultural Education group and the Others group excluding Agricultural Economics-Rural Sociology group in program B. The third set of dichotomy in program B which was analyzed was that of the Agricultural Education group and the Others group, excluding the Agricultural Economics-Rural Sociology group. Sixty-six students represented the Agricultural Education group and 61 students, the Others group. Calculations in PENNSTAC yielded the following one-term discriminant function: $y = -0.3524X_3$. It could be seen that only one variable, X_3 (the 4-Part Total Score on the Moore-Castore Aptitude Test), was found to be significant in the separation of the two subgroups involved. The Agricultural Education group made significantly lower 4-Part Total Scores (X_3) than the Others group. When tested for significance, this one-term function yielded an F-value of 17.7 which is highly significant. The null hypothesis of no significant discrimination between the Agricultural Education group and the Others group in program B is rejected on the basis of the evidence found.

Before leaving the discussions on the results of the analysis for testing the different null hypotheses, certain observations which the investigator thinks to be of considerable importance in conducting similar studies need to be pointed out. First, the preliminary analysis of variance need not be done if a digital computer like PENNSTAC is available. Second, an investigator does not have to decide which variables need to be retained since PENNSTAC and similar digital computers define the various equations as the elimination procedure takes place. This allows the investigator to select the equation which he thinks best suits his purposes. Third, insight should be exercised in deciding which independent variables are to be involved. Personality measurements do not seem to possess discriminatory qualities, or it might be that at this stage of development, personality tests and inventories have not attained some degree of re-

finement and validity. Investigators who plan similar studies will save time and effort in the numerous calculations entailed by the technique of discriminant analysis if attention is placed on the points brought out here.

Separation beyond college. To collect evidence supporting separation beyond college, the graduates of the original two programs of course work numbering 220 were surveyed for occupational placement with the use of a questionnaire. Two hundred twenty questionnaires were sent out and of this total, 18 were returned as the addressees could not be located. Of the 202 questionnaires which presumably reached the addressees, 143 were returned. However, only 132 of these questionnaires were usable. Table 10 shows the number of respondents by program and year of graduation.

TABLE 10.—*Number of respondents by program and year of graduation*

PROGRAM FROM WHICH GRADUATED	YEAR OF GRADUATION			TOTAL
	1956	1957	1958	
A	15	20	24	59
B	22	23	28	73
Total	37	43	52	132

The questionnaire was designed to collect information other than occupational placement. This section of the report deals with finding evidence as to how well the recognized and proven separation of two programs of undergraduate training correspond with the actual state of affairs, i.e. the occupational placement and/or plans of the graduates of the two programs of course work. Table 11 summarizes the findings in regard to job placements of graduates in relation to their undergraduate training. Caution should be exercised in interpreting these data. It should be recognized that job placement is not the function solely of undergraduate training. There are certain factors such as economic conditions, job opportunities, salary rates, etc. that affect job placement. In table 11, the combined percentage of items 1 and 5A (27 + 25.0) indicates that 52 per cent of the graduates in program A who completed and returned the questionnaire were in jobs definitely in line with their undergraduate training. This total could be increased to about 75 per cent if item 4A and at least a half of items 2 and 4B were added. Of

the graduates of program B who completed and returned the questionnaire, only about 43.4 per cent (the sum of percentages for items 1 and 5A) could be said to be definitely in jobs in line with their undergraduate training. If the percentage for item 4A and one half that of items 2 and 4B were added to 43.4 per cent, the total would increase to about 65 per cent.

TABLE 11.—*Job placement in relation to undergraduate program*

JOB PLACEMENT AND/OR PLANS	PROGRAM A GRADUATES		PROGRAM B GRADUATES	
	number	*per cent*	*number*	*per cent*
1. In job fully in line with undergraduate training	16	27.0	27	38.0
2. In job only partly in line with undergraduate training	15	25.0	12	16.4
3. In job definitey not in line with undergraduate training	2	3.5	4	5.4
4. In the armed forces:	(10)[a]	(16.5)	(19)	(25.4)
A. After tour of duty will return to job in line with undergraduate training	4	6.5	8	10.8
B. After tour of duty, will return to job not in line with undergraduate training	4	6.5	6	8.0
C. After tour of duty, will remain in the armed forces	2	3.5	5	6.6
5. In graduate work:	(16)	(27.5)	(8)	(10.8)
A. In graduate work in line with undergraduate training	15	25.0	4	5.4
B. In graduate work not in line with undergraduate training	1	2.5	4	5.4
Unemployed	—	—	3	4.0
Total	59	100.0	73	100.0

[a] Numbers in parenthesis represent total for the item.

The graduates also indicated their preferences as to program of course work to follow if they had the chance to undergo undergraduate training again. Although the question they answered was hypothetical, their preferences reflected, it seems, important information regarding their thinking about the two programs of course work they had undergone in relation to their present job placements. Table 12 shows the responses of the graduates to the question.

The data for the program B graduates in Table 12 agree with the interpretation of the data for the same graduates in table 11. About two-thirds of these graduates were in jobs in line with their

undergraduate training and about the same proportion indicated their preference for the same undergraduate training that they had undergone if they were to go to college again. The data for program A graduates in tables 11 and 12 show some discrepancy. In table 11, the estimated percentage for job placement including job plans was about 75 per cent. However if one does not consider the contributions of items 2 and 4B to the total, the percentage would be about 60 per cent and would agree with the data in table 12.

TABLE 12.—*Preference of graduates as to program of course work if they were to undergo undergraduate training again*

PREFERENCE	PROGRAM A GRADUATES		PROGRAM B GRADUATES	
	number	*per cent*	*number*	*per cent*
Emphasize courses that will prepare for research work, graduate studies, or employment in science areas	37	62.7	23	32.7
Emphasize courses that will prepare for practical, applied, or business pursuits in agriculture	22	37.3	50	66.3
Total	59	100.0	73	100.0

Perhaps one-half of items 2 and 4B should not be added to the total for those in program A whose job placement and plans are definitely in line with their undergraduate training. The sum of the percentages of items 2 and 4B (25.0 + 6.5) or 31.5 per cent might be taken as evidence of the movement towards a more general program of higher education—a movement away from too much specialization in science and research. The data in table 10 for the program A graduates seem to support the preceding contention. On the other hand, the data for the program B graduates in table 12 seem to run counter to the movement indicated by the data for the graduates of program A. The thinking of the graduates (about 33 per cent of them) of the more general, applied or practical curricula seems to indicate a need for more science and research courses. If these data interpretations in tables 11 and 12 are accepted as valid, then the data corroborate the thinking of many present-day college educators on the establishment of common programs for all college students in the first year, or in some institutions, in the first two years.

In relation to the primary purpose of the survey, that of adducing evidence of separation of the two groups beyond college, the

data in tables 11 and 12 indicate that more than 50 per cent of the graduates who were included in the survey had jobs and job plans which were definitely in line with their undergraduate training. The investigator does not consider this finding to be a conclusive evidence of the separation of the programs of course work carried beyond college into job placements. There are other factors perhaps more important than undergraduate training that affect job placements and job plans. Separation in undergraduate training might have contributed to the separation in job placement and job plans to a lesser or greater degree but unfortunately such a degree cannot be measured accurately with the materials and the technique involved in this study.

Other survey findings. In thinking about the use of the discriminant functions found in this study, an insight into the counseling situation, particularly the use of the independent variables involved in this study would provide ideas as to how the discriminant functions could be used effectively.

Table 13 shows whether or not the graduates on entering college sought counsel in choosing their curricula.

TABLE 13.—*Counsel in the choice of curriculum*

RESPONSE	PROGRAM A GRADUATES		PROGRAM B GRADUATES	
	number	*per cent*	*number*	*per cent*
Sought counsel in selecting curriculum	31	52.7	44	60.3
Did not seek counsel in selecting curriculum	28	47.3	29	39.7
Total	59	100.0	73	100.0

In both groups of graduates, more than one-half stated that they sought counsel in the choice of their curricula. The persons with whom these graduates sought counsel are shown in table 14. Although it can be seen that the graduates counseled with many persons in selecting their curricula when they entered college, almost all, except one, stated that their decisions on curriculum preference were primarily personal.

An encouraging aspect of the data presented in tables 13 and 14 is the fact that more than one-half of the graduates sought counsel with many persons when they were deciding on the curriculum they were to follow.

TABLE 14.—*Persons with whom the graduates sought counsel in choosing their undergraduate curricula*

PERSONS	NUMBER OF TIMES MENTIONED
Parents	68
High school teachers	54
Counselors, Counseling Division, P.S.U.	9
Staff members, Resident Education Office, C.A.	7
Staff members, Major Department	18
Others	26

The graduates were also asked if they were aware of the results of the tests on aptitudes, personality traits, and interests, which they took upon entering college, and in the selection of their curricula. Table 15 summarizes the responses to the question.

TABLE 15.—*Awareness of the graduates of the results of the aptitude, personality trait and vocational interest tests which they took on entrance to college*

RESPONSE	NUMBER	PER CENT
Aware of the results	33	25.9
Not aware of the results	94	74.1
Total	127	100.0

It can be seen that almost three-fourths of the graduates were not aware of the results of the tests which they took on entering college. Many of them could not even remember whether they took the tests or not. Many of those who reported that they were aware of the results stated that they knew of the results during the orientation week, or after they had registered. Many also reported taking the tests during the orientation week. When these graduates were asked whether or not the results of the tests were used in counseling sessions, about one-half believed that they were not (table 16).

TABLE 16.—*Use of the test results in counseling*

RESPONSE	NUMBER	PER CENT
Results were used in the counseling session	12	9.4
Results were not used in the counseling session	63	49.6
Result might have been used but not aware that they were used	52	41.0
Total	127	100.0

Only nine per cent definitely stated that the results of the aptitude, personality and interest testing were used in the counseling session. About 50 per cent said that the results were not used; and about 41 per cent stated that the results might have been used but they were not aware that these results were used. In spite of the fact that almost 26 per cent (table 15) claimed that they were aware of the results of the tests, only nine per cent definitely stated that the results were used in the counseling sessions they had with some persons, presumably from the Counseling Division, Office of Resident Education, or from the staff members of their major departments or with other persons.

When the graduates were asked what they thought should be done with the results of the aptitude, personality trait and vocational interest tests, they had several suggestions which are summarized in table 17. From the data presented in the table, it can be seen that the graduates did see some usefulness of the test results. They thought that the results should be known to the students before they register and that these results should be used more frequently in counseling sessions, particularly in the choice of a curriculum. However, the suggestion that the results be used as the primary basis for the selection of the curriculum was mentioned only 10 times. That the results should not be used was mentioned only three times. The data presented in tables 13 to 17 show that not much is being done with the results of aptitude, personality and vocational interest testing.

TABLE 17.—*Suggestions of the graduates on the use of the results of aptitude, interest, and personality tests*

SUGGESTION	NO. OF TIMES MENTIONED
Results should be known to the students before registering	69
Results should be more utilized in sessions in the choosing of a curriculum	59
Results should be used as the primary basis for the student in deciding which curriculum to follow	10
Results should not be used	3
Results should be known to parents	1
Results should be used in combination with other factors	1

The findings in this study that groups of students can be significantly separated from each other on the basis of linear combina-

tions of aptitude and vocational interest scores should prove very useful in counseling students in the choice of a curriculum.

CONCLUSIONS AND RECOMMENDATIONS

From this study, the following conclusions are tenable:

1. In so far as the purposes and design of the study are concerned, the preliminary analysis of variance wherein the variables were independently considered is of limited value. The availability of PENNSTAC to do the calculations, which included the elimination of insignificant independent variables, made the analysis of variance an unnecessary step in discriminatory analysis. Furthermore, indications of significant or insignificant differences from the analysis of variance could be misleading since consideration of possible inter-relations were not accounted for.

2. Since the discriminant functions for the major and subsidiary separation problems showed significance when tested, all the null hypotheses are to be rejected. Evidence shows that on the basis of a linear combination of variables X_1, X_3. X_7, X_{12}, and X_{14}, the individuals who enter and are able to graduate from the two programs of course work can be separated. Also, evidence shows that the recognized subgroups within each of the two programs of study can be separated from one another on the basis of certain variables. It was shown by the significant discriminations between subgroups that separations between more specific categories than the two programs of course work could be achieved. The validation of the major discriminant function showed that it can predict classification of individuals into either of the two programs of course work with reasonable efficiency.

3. For discriminatory analysis, measurements from the Bernreuter Personality Inventory are of very limited usefulness. Not one of the variables representing the measurements from the Inventory was included in any of the significant discriminant functions. On the other hand, measurements from the Moore-Castore Aptitude Test and the Strong Vocational Interest Inventory proved to be significant variables included in the discriminant functions. The high school graduation rank was also found to be useful in the discriminatory analysis.

4. Evidences of separation beyond college could not be considered conclusive because many factors that affect job placement

could not be controlled. Obviously, job placement is not the function solely of undergraduate training.

5. The results of the survey on the use of the measurements in counseling sessions held to help individuals in choosing the undergraduate curricula, indicated that these measurements were not fully used to advantage either by the students or the counselors and faculty advisers.

6. In the study, the technique of discriminant analysis proved its usefulness in resolving problems of classification. With digital computers available to do the enormous amount of computation, the technique should find increased applications in educational and psychological research.

The following are therefore recommended:

1. The information that the students who follow program A course work can be significantly discriminated from the students who follow program B course work should be used in counseling with students to help them choose the course work where they best belong. In practice, using the information means finding a student's individual y-value by means of the discriminant function,

$$y = -0.1367X_1 + 0.2201X_3 - 0.3255X_7 + 0.0066X_{12} + 0.2011X_{14},$$

and comparing this value with the critical score to determine whether or not the student belongs in program A course work or in program B course work. In making this recommendation, the investigator is advocating a positive and a firm counselor attitude to tell the counselee the program of course work to which he best belongs. Present-day counselor diffidence in making positive recommendations arises out of the policy of non-directive counseling in many institutions. Yet many counselors would go or would want to see researchers go at great lengths to arrive at well founded facts. The efficient use of the discriminant function requires that the results of aptitude and interest testing be known to the students and counselors as early as possible and not later than registration day.

2. The use of the discriminant functions derived from the analysis made on the subgroups under each of the two major groups should be held in abeyance pending their proper validation. It should be pointed out that these functions apply to separations into more specific categories, i.e., specific curricula, and groups of very closely allied curricula and therefore, their use would be more exacting,

not to say meaningful. Separation into specific curricula should be the goal in curricular guidance.

3. Regression equations that predict probable success should be determined for each of the groups that have been significantly discriminated. When this is done, an interesting study could be devised to combine into a single index number the joint-probability of membership and success as initially worked out by Tatsouka (1956).

4. Studies similar to the present one should be conducted for the other colleges of the University, especially those units which have heterogenous curricular offerings.

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APPENDIX A
Sample Code Sheets for PENNSTAC

PENNCODE CODING SHEET

Problem: Student Separation

Page: 1
Date: .....

Track: .....

Tape No.: .....

Coder: Saguiguit

WORD LOC.	S	1	2	3	4	5	6	7	8	9	0	NOTATION
0705											1	Print cross-products
0796											1	Print correlation matrix
0779										1	6	No. of variables
0506										1	7	Size of correlation matrix
0780		2	2	0								No. of replications
0715									2	2	0	No. of check sums
0740											1	No. of replication/block
0774											1	No. of replication in last block
5000											0	End of parameter road-in

WORD LOC.	S	1	2	3	4	5	6	7	8	9	0	NOTATION
5000				0	2							X_1
5000				0	9	1						X_2
5000				1	2	0						X_3
5000				0	2							X_4
5000				0	2							X_5
5000				0	2							X_6
5000				0	4							X_7
5000				0	6							X_8
5000				0	8							X_9
5000				0	4							X_{10}
5000				0	4							X_{11}
5000				0	5							X_{12}
5000				0	9							X_{13}
5000				0	7							X_{14}
5000				0	9							X_{15}
5000				0	9							X_{16}
				9	4	1						Check sum

PENNCODE CODING SHEET

Problem: Student Separation

Page: 112
Date: .....

Track: .... Tape No.: .....

Coder: Saguiguit

WORD LOC.	S	1	2	3	4	5	6	7	8	9	0	NOTATION
0788										1	6	
0430											0	
0715											1	
5000											0	
0430	–		1									X_1
0432	–		3									X_3
0436	–		7									X_7
0441	–	1	2									X_{12}
5000			3	8	9							$F_{1,203}$
5000			6	0	8							$2F_{2,203}$
5000			7	9	5							$3F_{3,203}$
5000			9	6	4							$4F_{4,203}$
5000		1	1	3	0							$5F_{5,203}$
5000		1	2	8	4							$6F_{6,203}$
5000		1	4	3	5							$7F_{7,203}$
5000		1	5	8	4							$8F_{8,203}$
5000		1	7	2	8							$9F_{9,203}$
5000		1	8	7	0							$10F_{10,203}$
5000		2	0	1	3							$11F_{11,203}$
5000		2	1	6	0							$12F_{12,203}$
5000											0	

WORD LOC.	S	1	2	3	4	5	6	7	8	9	0	NOTATION

APPENDIX B
Portions of PENNSTAC Output

PENNSTAC Output (Machine printed with annotations by the investigator, middle and right hand columns)

Out 5.128 Saguiguit 2-16-59

Student Separation

PORTION OF CORRELATION MATRIX

00002142318	$(X_1 - \overline{X}_1)^2$	
00010688544	$(X_2 - \overline{X}_2)^2$	Corrected sum of squares
.....	.	
.....	.	
.....	.	
.....	.	
00006548000	$(X_7 - \overline{X}_7)^2$	
.....	etc.	
00004126317	$(X_{16} - \overline{X}_{16})^2$	Last independent variable is X_{16}
05500000000	Check sum	
00099999993	$r_{1,1}$	
00029756107	$r_{1,2}$	
.....	.	
.....	.	
.....	.	
00014620069	$r_{1,16}$	Correlation matrix (Correlation coefficients
00100000000	$r_{2,2}$	are given for all pairs of variables)
00097009497	$r_{2,3}$	
.....	etc.	
.....	.	
.....	.	
.....	.	
00028425907	$r_{15,16}$	X_{16} is the last independent variable
00100000000	$r_{16,16}$	X_{17} is the manufactured variable
00021573506	$r_{16,17}$	
00100000000	$r_{17,17}$	

Portions of PENNSTAC Output: Correlation Matrix and Definition of Equations
(Annotations by the investigator)

PORTION OF THE LAST BLOCK SHOWING DEFINITIONS OF EQUATIONS AS ELIMINATION OF INSIGNIFICANT VARIABLES TOOK PLACE

Out 5.128 Saguiguit 2-16-59

Student Separation

00000000001 (1st equation)	00000000000	00059493253 (Residual variance)
−00100000000 (X_1)	−00013141808 (b_1)	00000368339 ($S^2_{b_1}$)
00200000000 (X_2)	−00030458532 (b_2)	00005344920 ($S^2_{b_2}$)
00300000000 (X_3)	00048810695 (b_3)	00005454696 ($S^2_{b_3}$)
00400000000 (X_4)	−00012586793 (b_4)	00001058155 ($S^2_{b_4}$)
..... etc.	..... etc.	..... etc.
01600000000 (X_{16})	−00002511313 (b_{16})	00000468673 ($S^2_{b_{16}}$)
00000900002 (2nd equation)	00000000013 (X_{13} eliminated)	00059509297 (Residual variance)

Columns continue in the same manner as above until all insignificant variables are eliminated and the final equation is defined. The insignificant variables eliminated were X_{13}, X_{16}, X_4, X_{15}, X_6, X_9, X_8, X_2 X_{10}, X_5, and X_{11} in the order they are mentioned. The final equation was the 12th equation and was defined as follows:

00000000012 (12th equation)	00000000011 (X_{11} eliminated)	00065240110 (Residual variance)
−00100000000	−00013674994 (b_1)	00000337833 ($S^2_{b_1}$)
−00300000000	00022006585 (b_3)	00000355652 ($S^2_{b_3}$)
−00700000000	−00030551580 (b_7)	00000474062 ($S^2_{b_7}$)
−01200000000	00000660240 (b_{12})	00000741720 ($S^2_{b_{12}}$)
01400000000	00020114929 (b_{14})	00000834208 ($S^2_{b_{14}}$)
00002054458	00000000014	−00000000980

(Last row of values shows that X_{14} was tested but was not eliminated. The 1st value is the significant F-ratio, the third value in the row is the index of accuracy of inversion.)

RETAILING RICE IN SELECTED AREAS[1]

DALMACIO A. CRUZ

WITH FOUR TEXT FIGURES

The purchasing test showed that only eight per cent or 2 out of 25 gantas sampled reached a full ganta, 3 liters, measure. An equal proportion of the purchases were short of a full ganta by nine per cent. The average volume was nearly four per cent less than a ganta. Essentially, this means that for every 25 gantas bought, the retailers were selling 26 gantas. Price-wise, it means that consumers were paying 5 to 6 centavos more per ganta for rice than the price tag indicated. As an average, the gantas bought were 89 grams or over three per cent short. In general, the samples studied, except the NARIC rice, were of the Wagwag variety which was from 93 to 99 per cent pure, or an average of about 96 per cent.

The series of merchandising tests gave promising results: rice buyers preferred to buy rice (1) in prepackaged form using plastic bags and (2) from improved rice sales bins. The first and second prapackaging experiments showed that 61 and 66 per cent, respectively, of the total buyers expressed preference for plastic over paper bags as rice containers. Other tests also indicated consumer acceptance of both plastic bags and the use of sanitary rice sales bins. In all of the merchandising tests, rice sales increased considerably.

Consumers usually purchase rice from open bulk display where only the price, and generally the variety and/or class are identified. It is doubtful if this system of retailing rice has ever been considered seriously by the consumers. The housewife reacts toward the price by buying happily when the price is low, and buying anyhow when the price is high. Apparently little consideration is given to such factors as accuracy of measure, purity of variety, proportion of broken grains, and sanitation in retailing.

PURCHASING TEST

The purchasing test was conducted primarily to determine what consumers get when they buy rice. Among other things, the test showed that (1) consumers do not usually obtain a full ganta when they buy rice and (2) the presence of admixture and broken grains

[1] Central Experiment Station Contribution No. 2049. Part of Project No. 1184. Partly supported by R.A. 1606 funds.

was evident in all samples of Wagwag rice studied. There was no sure way of buying to minimize these defects.

Method. Briefly, the procedure followed was to buy one ganta of milled Wagwag rice from 25 rice retailers in Manila, Rizal, and San Pablo, Laguna. The purchases were made by a staff member of the Department of Agricultural Economics. This particular staff member posed as a typical neighborhood rice buyer. The College vehicle used for this purpose was parked some distance from each store where purchases were made. This arrangement was necessary in order not to arouse the suspicion of the retailers and thus reduce bias in pricing and measuring the purchased rice. Where there were more than one class of the variety in a retail store, the highest in price was selected. The data were analyzed in the Agricultural Economics department.

A 1,000 ml. graduated cylinder was used in measuring each sample. After keeping the samples at room temperature for 12 days, their weights were individually determined on an Ohaus Solution Balance. Fifty grams taken at random from each sample were prepared to determine the moisture content, using a Universal Moisture Tester. The ratio of broken grains was chosen at random from each ganta. The proportion of admixtures was also determined by count.

Prices. Prices of Wagwag rice varied quite widely, even in the limited geographical area where this test was conducted. Prices, excluding those in NARIC stores, averaged ₱1.46 and ₱1.39 per ganta in Manila and in stores within a 30-kilometer radius from Manila, respectively (table 1). Lowest prices were found in the

TABLE 1.—*Retail prices of Wagwag rice by locality, 25 retail stores, 1958*

LOCALITY	NUMBER OF STORES	RETAIL PRICE PER GANTA
		pesos
Within Manila:		
Excluding 1 NARIC store	7	1.46
Including 1 NARIC store	8	1.39
Within 30 km. of Manila	6	1.39
Beyond 30 km. of Manila:		
Excluding 1 NARIC store	10	1.30
Including 1 NARIC store	11	1.28

stores more than 30 kilometers from Manila. In these stores prices averaged ₱1.30 a ganta or 16 centavos less than in Manila.

Volume. The standard ganta is equivalent to 3 liters. However, the rice retailers have developed a technique of filling the ganta but putting in less than the said quantity. They do this by slanting the ganta to about 50 degrees instead of placing it upright when measuring rice. The practice, aided by consumer acceptance, has flourished through the years.

Significantly, only eight per cent or 2 out of 25 gantas purchased reached the 3-liter mark, as determined by a careful measurement of each sample (table 2).

TABLE 2.—*Characteristics of 25 gantas of Wagwag rice in 25 retail stores, 1958*

PRICE GROUP [a]	VOLUME [b]		WEIGHT [c]		PER CENT		
	Ml.	Per cent full measure	Gm.	Per cent full weight	Moisture content	Broken grains	Purity
Highest—average	2,914	97.1	2,367	97.4	33	13.2	96
Medium—average	2,908	96.9	2,390	98.3	32	13.1	96
Lowest—average	2,792	96.0	2,325	96.0	36	13.2	97
NARIC—average	2,845	94.8	2,331	95.9	73	13.0	57
All groups	2,894	96.5	2,341	96.8	37	13.2	94

[a] Highest price ranged from ₱1.45–₱1.50 per ganta; Medium, ₱1.35–₱1.40; and Lowest, ₱1.25–₱1.30. Two gantas from NARIC stores were each priced at ₱0.95.
[b] Full measure: 3,000 milliliters.
[c] Full weight: Assumed to be 2,430 grams.

An equal proportion of the purchases were nine per cent short of a full ganta. For all samples, the average volume was nearly four per cent less than a ganta. Essentially, this means that for every 25 gantas bought, the retailers were selling 26 gantas.

Considering this situation price-wise, the consumers were paying 5 to 6 centavos more per ganta of rice than the price tag indicated.

Weight. Assuming that a ganta of rice weighs 2.43 kilos, only two of the samples exceeded the standard weight. On the other hand, three samples were about eight per cent short in weight. As an average, the gantas bought were 89 grams or over three per cent short. Weight, or course, is influenced by the proportion of broken

grains and moisture content. Both of these factors may explain why the variation from the standard volume was greater than that from the standard weight.

Broken grains. Consumers' preference would be decidedly for whole grain rice. Much remains to be desired in this direction because 37 per cent of the grains for all samples analyzed were broken. This condition could be caused by any, or all of the following: poor milling, milling moist palay, admixtures. The price of the rice was not closely related to the proportion of broken grains. Within each price group, the proportion of broken grains varied quite widely. The range in proportion of broken grains was from 17 per cent to 52 per cent in the non-NARIC stores. The NARIC rice had over 70 per cent broken grains.

Moisture. The moisture content of the rice samples studied ranged from 12.5 to 14.5 per cent, or an average of 13.2 per cent.

Purity. Both hulled and unhulled Wagwag rice grains have a characteristic shape that easily distinguishes them from other varieties. The subclasses or other grades of Wagwag are generally based on the degree of impurity or mixing. Generally, the price is lower when there are more admixtures. Naric Wagwag had the lowest percentage of purity, hence the lowest retail price of ₱0.95 per ganta. In general, the other samples studied were relatively pure, ranging from 93 to 99 per cent, or an average of about 96 per cent.

MERCHANDISING TEST

The usual practice in retailing rice is for the sellers to measure rice and pack it in brown paper bags as the customers buy it. Sometimes the customers provide themselves with containers such as bamboo baskets or jute bags. In either case, the practice lacks sanitation and efficiency.

Prepacking. To determine the desirability of prepacking rice in plastic bags for sale to customers, a trial test was run for nine consecutive days in two selected retail stores in Los Baños, Laguna. The stores were provided with plastic bags and wire closing devices. A brief advertisement in the local dialect introducing the new rice container was conspicuously posted in the two stores. Several plastic bags were filled with rice by the enumerators and retailers and set up on the open bulk display. The volume of sales and the number of buyers, by type of chosen container, were recorded. During the

nine-day trial test, 242 customers purchased a total of 337 gantas of prepackaged rice as compared to 108 buyers who preferred paper as containers (table 3). Percentage-wise, this means that close to two-thirds (61 per cent) of the total buyers expressed a preference for prepackaged rice in plastic containers. Their aggregate purchases represented 58 per cent of the total gantas of rice sold during the experiment.

TABLE 3.—*Volume of rice sales and number of buyers by type of container chosen 2 retail stores, Laguna, 1958*

THREE-DAY PERIOD	PLASTIC BAG [a]		PAPER BAG	
	Number of gantas sold	Number of buyers	Number of gantas sold	Number of buyers
First 3 days	111.5	69	107.5	45
Second 3 days	118.5	89	63.5	28
Third 3 days	107.0	84	74.0	35
Total	337.0	242	245.0	108
Per cent of total	58	61	42	39

[a] Polyethylene, a synthetic which has recently become popular in packing fresh food products.

The trend of consumer preference was reflected in the increase of the number of buyers choosing plastic bags and the quantity of rice purchased during the test. The number of buyers that chose plastic bags as containers increased by almost 30 per cent and 22 per cent from the first to the second period and from the first to the third period of the test, respectively. This obviously meant a decrease in the number of buyers who preferred paper bags. However, the change in volume of sales with either type of container was not consistent. Rice sales using plastic bags was highest during the second period (118.5 gantas) but somewhat dropped during the third period. Sales in paper bags dropped sharply in the second period but increased in the third period.

Following the nine-day experimental period, the plastic bags and advertisements were completely withdrawn from the stores. However, the reactions of rice buyers were observed for two additional days. Of the 42 rice customers who came to the stores after the test, 28 or 66 per cent asked for plastic bags while only 14 or a third preferred paper bags (table 4). Significantly, in one of the stores, all customers asked for rice in plastic bags.

TABLE 4.—*Type of container requested by rice buyers two days following test in 2 retail stores, Laguna, 1958*

ITEM	NUMBER OF BUYERS WHO ASKED FOR	
	Plastic bags	Paper bags
Store "A"		
First day following test	10	8
Second day following test	8	6
Store "B"		
First day following test	6	0
Second day following test	4	0
Total	28	14

The brief study determined to a considerable extent consumer preference for and acceptance of plastic bags as rice containers. A similar test, broader in scale and somewhat modified, was conducted in six other stores, three each in Calamba and Sta. Cruz, Laguna, for a seven-week period. Like the first test, plastic bags and wire closing devices were provided free for use by the retailers in exchange for their cooperation. Tabulation sheets for recording daily retail sales of rice were also furnished the retailers. Almost every other day, the enumerator collected the sales data from each retailer and replenished their supply of test materials.

But unlike the previous experiment, only samples of prepacked rice in 1 and 2 ganta-sized plastic bags were placed in each store. The customers were each interviewed on their preference for rice containers. The purchases of a few buyers who brought their own containers and who usually bought more than a ganta of rice were not recorded on the list of daily sales. It should be pointed out that the cost of the test materials was disregarded, hence their use did not increase the prevailing retail prices of rice.

At the end of the seventh week, all stores had sold a total of 765 gantas in plastic bag containers as against 735 in paper bags (table 5). The sales represented 51 per cent and 49 per cent for plastic and paper bags, respectively. In terms of consumer preference for containers, the trend in sales was more impressive than the total sales. In general, consumer choice shifted from paper to plastic bags after the second week. During the first two weeks, sales in paper bags exceeded those in plastic bags. Thereafter, sales in plastic bags exceeded those in paper bags.

TABLE 5.—*Average weekly rice sales by type of container chosen 6 retail stores, Laguna, 1958*

WEEK	RICE CONTAINER		TOTAL
	Plastic bag	Paper bag	
		gantas	
First	96.2	107.8	204.0
Second	92.8	113.5	206.3
Third	104.8	94.2	199.0
Fourth	114.3	94.8	209.1
Fifth	122.3	110.5	232.8
Sixth	113.2	108.0	221.2
Seventh	121.8	106.3	228.1
Total	765.4	735.1	1,500.5
Per cent of total	51.0	49.0	100.0

The third series of rice merchandising tests combined the use of plastic bags as containers and the first model of the experimental rice bin as a sales case (fig. 1). This experiment was also run

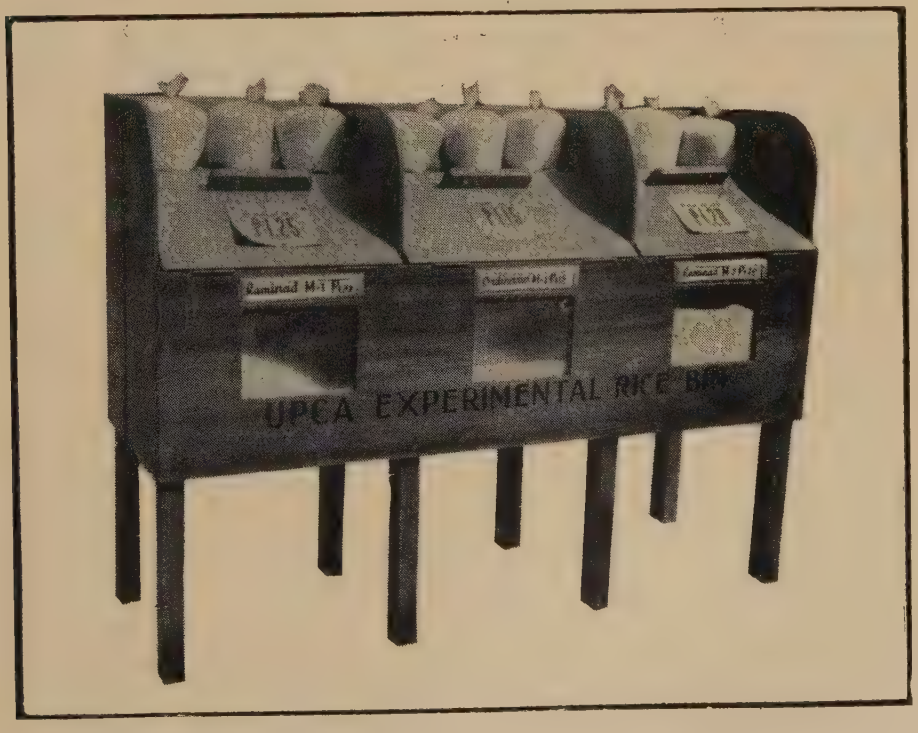

Fig. 1.—Experimental Rice Bin No. 1 (Front elevation) showing a display of prepackaged rice in ganta-sized bags, variety identification, and price tags.

for seven consecutive weeks at the NEFCA retail store in Cabanatuan City. The store's old open display bin was replaced by the experimental sales case for the duration of the test. Samples of prepacked 1- and 2-ganta units of rice in plastic bags were placed on the display shelf of the rice bin. As in the previous tests, a free supply of test materials was furnished the store and records of daily sales were kept by the store clerk. The enumerator visited the store at least once a week.

Limitations in the methodology of this experiment may have prevented the gathering of more valid results. The first of these limitations was the unavailability of daily sales records in ganta units prior to the test. This information could have served as a measure to determine the effects of the test materials on the volume of sales. Also, the NEFCA store, being a semi-government agency, could not meet the price competition of the 12 large private rice retailers who operated in the immediate vicinity. During the experiment these private retailers reduced their retail prices to a level of 5 centavos lower than the prices in the test store. As a result, NEFCA sales were affected adversely, the test materials not withstanding. Furthermore, the test store, lacking sales volume, failed to operate regularly during the latter part of the experiment, hence observations during the last two weeks were not considered in the analysis of the results.

In spite of these problems, however, rice sales in plastic bags were slightly higher than sales in paper bags (table 6). The distorted trend in the average weekly sales was probably the effect

TABLE 6.—*Average weekly rice sales by type of container chosen NEFCA retail store, Cabanatuan City, 1958*

WEEK	RICE CONTAINER		TOTAL
	Plastic bag	Paper bag	
		gantas	
First	17.5	13.5	31.0
Second	11.0	13.0	24.0
Third	22.0	22.0	44.0
Fourth	9.0	17.0	26.0
Fifth	13.0	6.0	19.0
Total	72.5	71.5	144.0
Per cent of total	50.4	49.6	100.0

of the price war waged by the private competitors rather than other factors.

Immediately after the test materials were withdrawn from the store, a follow-up observation on the reaction of the customers was made for one week. Although only 11 of the regular customers came back to the store during the week, 7 of them asked for plastic bags as containers, 3 preferred paper bags and 1 was not particular about the container (table 7).

TABLE 7.—*Post-effects of test materials during week following tests NEFCA retail store, Cabanatuan City, 1958*

ITEM	NUMBER OF CUSTOMERS	PER CENT OF TOTAL
Customers who asked for rice in:		
Plastic bag	7	64
Paper bag	3	27
No particular bag	1	9
Total	11	100
Customers who asked for rice from:		
Experimental sales bin	10	91
No particular bin	1	9
Total	11	100

Sales bin. The after effect of the test materials shows that 10 of the 11 customers asked the store clerk to sell them rice from the "modern" bin. According to the store clerk, his regular customers liked the new sales bin as the rice display was free from dust and germs. Furthermore, the glass windows of the new bin facilitated the buyers' selection of the class or variety of rice.

An improved model of the experimental sales bin (fig. 2, 3, and 4) was tested for four weeks in a store in Calamba, Laguna. The record of rice sales gathered in the previous packaging study in the same store provided a basis for measuring the effects of the test sales bin. Significantly, rice sales after the new bin was introduced increased by 24 gantas or better than 20 per cent over sales prior to the use of the bin (table 8). The volume of rice sales in paper bags dropped by 12 gantas or 22 per cent after the sales bin was set up in the store. Conversely, the sales in plastic bags increased by 36 gantas or nearly two-thirds after the bin was placed in the store. The loss in the number of customers buying rice in paper

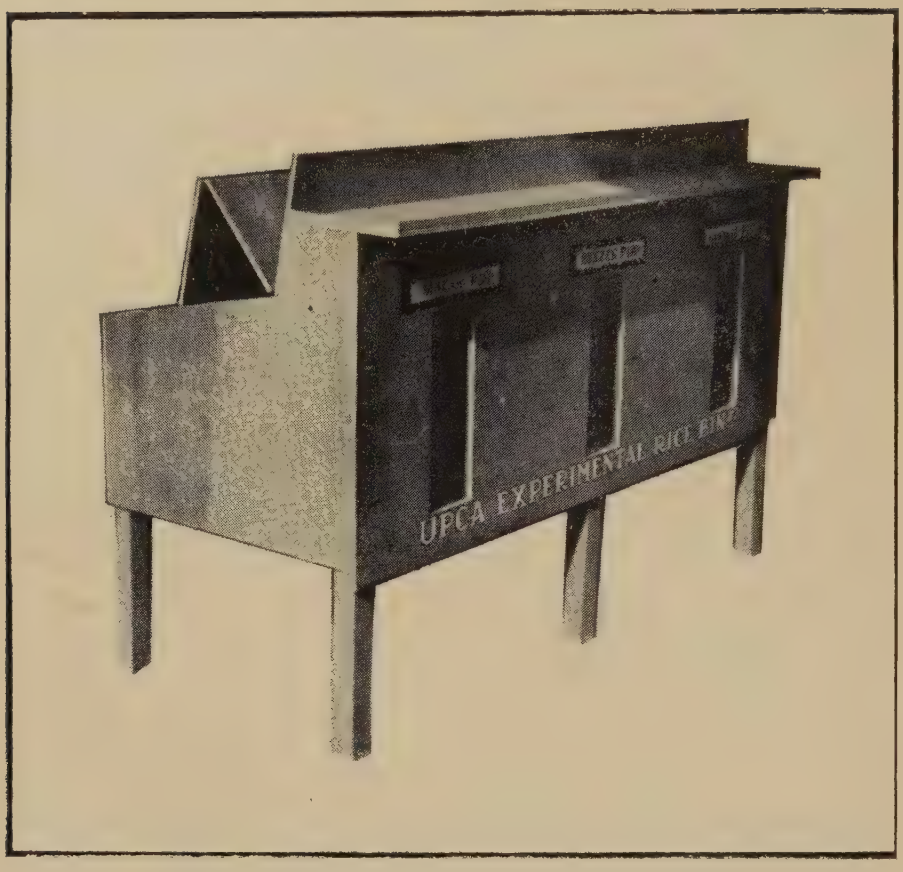

Fig. 2.—Experimental Rice Bin No. 2 (Front elevation). Inverted V-shape at rear shows one of hinged covers half-opened.

bags was less than the gain in customers purchasing rice in plastic containers, suggesting that new customers had been attracted to the store. Such a shift further suggests that consumers accepted the use of plastic bags as containers and especially desired retailing of rice in sanitary bins.

Another interesting aspect of the preceding experiment was the reaction of the town officials when invited to see the rice sales bin in actual operation at the test store. All of them—the town mayor, the health officer, the district engineer, and the chief of police—favorably indorsed the new rice bin and the prepackaging idea to the neighboring retailers. The health officer signified intentions to

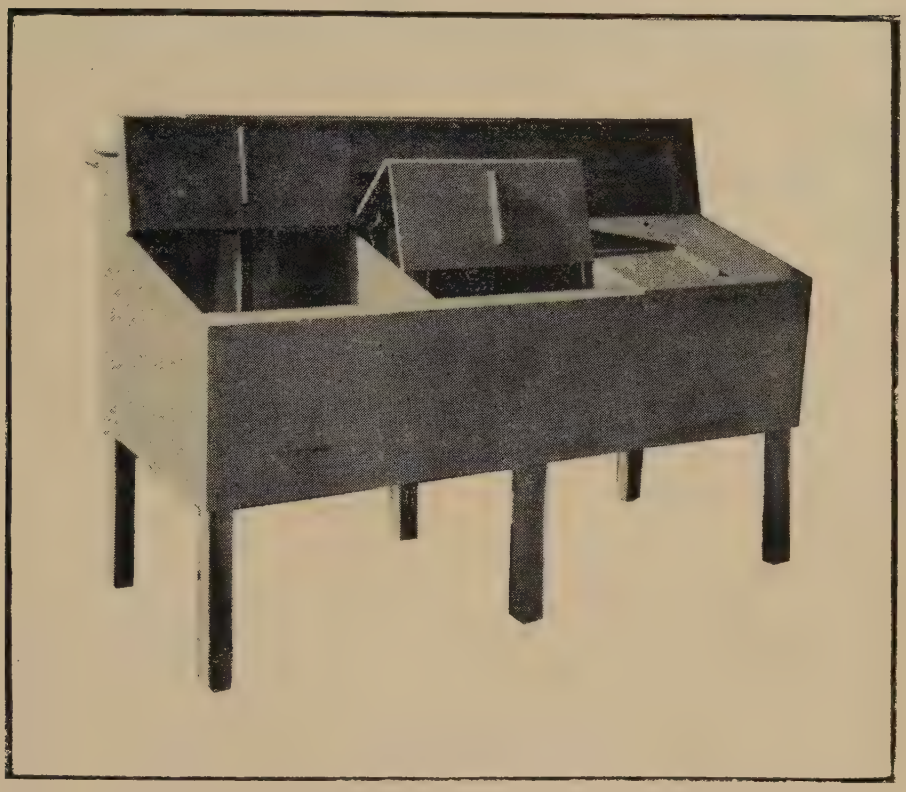

Fig. 3.—Rear elevation of Experimental Rice Bin No. 2 showing mechanism of folding hinged covers.

require the local retailers to adopt the covered rice bin as he requested a detailed plan of the experimental model.

TABLE 8.—*Consumer preference for rice containers 1 retail store, Laguna, 1958*

WEEK	NO SALES BIN [a]			WITH SALES BIN [a]		
	Plastic bags	Paper bags	Total	Plastic bags	Paper bags	Total
First	18.4	16.4	34.8	22.7	12.1	34.8
Second	14.1	14.1	28.2	23.0	11.0	34.0
Third	11.4	13.6	25.0	21.7	10.9	32.6
Fourth	11.9	12.4	24.3	24.9	10.0	37.9
Total	55.8	56.5	112.3	92.3	44.0	136.3

[a] Average sales in gantas.

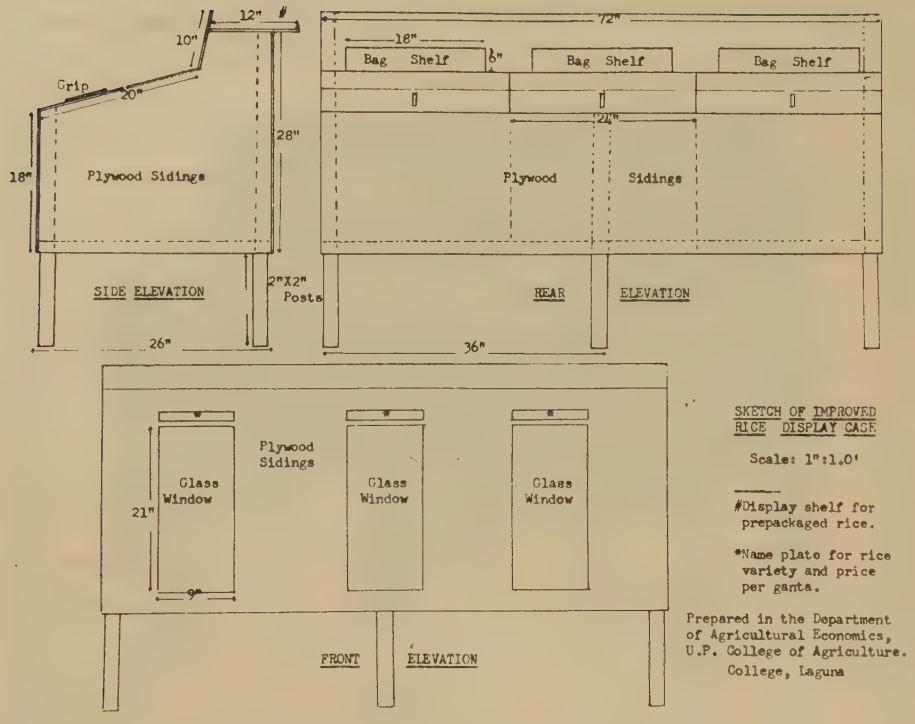

Fig. 4.—Plan of Experimental Rice Bin No. 2.

CONCLUSION

To bring about improvements in rice marketing, it is suggested that the following findings of this study on rice retailing be given attention by the government, and by all those engaged in the trade.

1. *Prepackaging.*—The desirability of prepackaging rice for sale to customers was demonstrated by the shift of buyers from purchasing rice in bulk display to prepackaged units. This trend of consumer preference strongly suggests the widespread use of prepackaging from the standpoint of sanitation and efficiency. It also suggests the possibility of prepackaging rice at the rice mill to do the job efficiently, control quality, and insure a full measure of rice.

2. *Sales bins.*—Like the encouraging results of the prepackaging test, the use of covered sales bins which makes possible sanitary

rice retailing offers promising results. Special sales bins have possible use in the retailing of other food items such as fresh meat, fish and baked goods. Used widely, sales bins could markedly improve the unsanitary methods prevalent in food retailing.

3. *Enforcement of standard weights and measures.*—Government officials should enforce the use of legal standard weights and measure in the rice retailing business. At the same time, rice buyers should be encouraged to demand full measure of the ganta in their purchases.

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